Taught Masters Module Guide

The Lancaster Environment Centre

LANCASTER UNIVERSITY

LEC Taught Masters Module Guide

Please note that this module guide is provided for guidance only and modules are subject to change.

LEC Taught Masters for 2013/14:

- MSc Contamination, Risk Assessment and Remediation
- MSc Ecology and Conservation
- MSc Energy and the Environment
- MSc Environmental and Biochemical Toxicology
- MA/MSc Environment and Development
- MA/MSc Environment, Culture and Society
- MA Environmental Management and Consultancy
- MSc Environmental Science and Technology
- MSc (Research) International Master's in Environmental Science and Technology
- MSc Resource and Environmental Management
- MSc Sustainable Agriculture and Food Security
- MSc (Research) International Master's in Sustainable Agriculture and Food Security
- MSc Sustainable Water Management
- MSc Volcanology and Geological Hazards

MODULE NUMBER: BIOL 405		MODULE TITLE: BIOLOGICAL EFFECTS OF AIR POLLUTION AND CLIMATE CHANGE	
Number of weeks: 5	Term taught: L1	Contact hours: 15	Learning hours: 150
Pre-requisites: None		Co-requisites: None	Credits: 15
***Module Organiser*:** Prof Bill Davies		***Other lecturers***: Dr Martin McAinsh, Dr Gerhard Kerstiens, Dr Sally Wilkinson	

Aims and Scope: To provide an overview of the various components of global environmental change (global warming, ozone depletion, elevated CO_2, tropospheric air pollution) and an in-depth analysis of their biological impacts. The principal focus will be on ecological responses across a range of scales from the organism to the ecosystem. Human impacts are also consideredThe subsequent assignment will provide experience of providing a comprehensible written expression of the scientific complexities surrounding issues of significant public concern.

Syllabus

Week 1 Climate change: science and politics In this combination of an introductory lectures and workshops, you will have the opportunity to assess data on global warming and its effects on matters of day to day concern. We will also assess treatment of this topic by politicians and the media. The course work assessment will also be introduced this week.	BD
Week 2 Air pollutants: plants as our garbage chutes. Atmospheric deposition processes of gaseous pollutants and mediation of their uptake into leaves by plants	GK
Week 3 Tropospheric air pollutants and effects on biological systems These lectures will consider air pollutants in the lower atmosphere (troposphere), notably ozone pollution. Tropospheric ozone remains a major element of local and regional pollution, reducing air quality with wide-ranging ecological consequences.	MRM
Week 4 Interacting effects of ozone and other abiotic stresses a) Plants. These lectures will deal with the interacting effects of different stresses within a changing climate. Impacts of these effects on global food security will be the focus of this section of the course. A case study on the Indo-Gangetic plain will illustrate how both science and social science are needed to help ameliorate the effects of climate on food supply for the region	SW
b) Human Health.	GK
Week 5 Acidifying pollutants: it's crystal clear, isn't it? Effects of acidifying pollutants on vegetation and ecosystems	

Learning outcomes.
You will obtain a balanced knowledge of the current state of knowledge concerning key elements of global change and the ability to critically assess the available data and less formal information relating to the subject. You will gain experience of preparing concise reports that present complex information in a style accessible to a non-specialist audience. The case study from India will be designed to show how science can be put into practice to help ameliorate the effects of climate change

Assessment: Exam 50%, CWA 50%

Details of CWA. There will be one piece of course work, in which a topic of the student's choice will be presented in the style of a concise briefing document. A balance is required between effective use of the primary literature and communication in an accessible style, and obtaining this balance forms part of the learning process.

Recommended learning resources. For the most part reference will be made to the primary literature and, in some cases, published reviews. All sources will be provided in lectures and materials will be available on-line or as hard-copies.

MODULE NUMBER: BIOL 420	MODULE TITLE: FOOD SECURITY, AGRICULTURE AND CLIMATE CHANGE		
Number of weeks: 5	*Term taught: L1*	*Contact hours:* 24	*Learning hours: 150*
Pre-requisites:		*Co-requisites:*	*Credits: 15*
Module organiser: **Professor Bill Davies (WJD)**		***Other lecturers:*** Dr Sally Wilkinson (SW), Dr Martin McAinsh and guest lecturer(s)	

Aims and scope:
Food security is achieved when all people have access to an adequate supply of safe and nutritious food. Currently there are around one billion people who are inadequately fed and this number is likely to double in the next 30 years. The aim of this module is to describe the food system and the range of issues that ultimately determine who eats what. We address issues contributing to variation in food availability, the access that people have to food and the different ways in which food is utilised. The module will address ways in which crops accumulate biomass and undergo reproductive development. This will allow the consideration of why crop plants are so sensitive to biotic and abiotic stress and why there is so much concern about the effects of climate change on food availability and food prices. The impact of the food production system on the environment is considered and along with the tensions arising from our quest for both food security and energy security. Factors impacting food safety and quality are discussed. The approach to the study of these issues is interdisciplinary in nature. The course takes an international perspective on GFS (Global Food Security)

Syllabus

Lecture sessions	**Title**	**Lecturer**
1	**The interdisciplinary basis of Food Insecurity and the shortage of resources for food production**	WJD
2	**A fair and just food system**	Guest
3	**Environmental stress and crop yield**	WJD/SW
4	**Plant Breeding/Crop Improvement for yielding under drought and GM. Crop management systems, the environmental impact of agriculture**	WJD/SW
5	**Food safety and quality**	WJD/Guest
Workshop sessions include consideration of:	**Title**	**Lecturer**
1	**Agriculture other ecosystem services and climate change.**	WJD
2	**The Royal Society report on Science for Enhancing Food Production/Foresight Report on Food and Farming.**	WJD
3	**Factors impacting food availability, access and affordability**	WJD
4	**Novel crop and resource management systems**	WJD
5	**Biofuels** We will explore the potential for biofuel production, the capacity of bioenergy to contribute to meeting global energy demands and the social / ecological implications of replacing produce for energy crops.	WJD

***Learning outcomes*:**
On completion of this module a student should be able to:

- Understand the component parts and the interdisciplinary basis of the food system
- Detail the challenges facing global agricultural production as a result of climate change
- Understanding of the shortage of key resources for food production
- Understand the issues affecting peoples' access to food
- Have some understanding of factors impacting food safety food quality
- Detail the problems posed for plants growing in dry soil, at high temperature and in high ozone concentrations
- Demonstrate how basic plant physiology can inform both plant breeding and agronomy to increase the sustainability of agriculture.
- Familiarity with several current/impending crises in global food security

Assessment: CWA: 50% Exam: 50%

Details of CWA:
A report and presentation on one of the components of the food system (issues underlying the delivery of food security)

Recommended texts and other learning resources:

- Reaping the Benefits. The Royal Society 2009
- Foresight Report on Food and Farming 2011
- Other texts supplied
- Seminars from outside speakers

MODULE NUMBER: BIOL421	MODULE TITLE: DATA ANALYSIS AND INTERPRETATION		
*Number of weeks: **10***	*Term taught: L1/ 2*	*Contact hours: 40*	*Learning hours: 150*
Pre-requisites: 'A' level maths or ENV.460		*Co-requisites: None*	*Credits: 15*
Module organiser: Dr Andrew Titman (M&S)		***Other lecturers:***	

Aims and scope: A full first course in statistics and data analysis from a non-mathematical viewpoint. Covering both parametric and non-parametric methods, up to and including generalised linear models.

Syllabus

Lecture	**Title**	**Lecturer**
1	Data types, summaries, graphs, statistics, parameters	Titman
2	Estimation and testing	
3	Continuous response with categorical covariate	
4	Continuous response with continuous covariate	
5	Continuous response - the general linear model	
6	Categorical response with categorical covariate	
7	Sampling strategy and design of experiments	
8	Discrete binary response: logistic regression	
9	Discrete count response: log-linear regression	
10	Class test.	
Practical/workshop	**Title**	**Lecturer**
	As above; no formal practical on weeks 2 (students can continue with the lab from week 1) or 7 (students should be completing CW1).	Titman

Learning outcomes:
On completion of this module a student should be able to: design a sensible experiment or sampling scheme; perform and interpret an exploratory analysis of the data; decide on a sensible statistical analysis, including a choice between parametric and non-parametric testing, if relevant; perform that analysis in SPSS and interpret the results. Students should also be able to realise when the analysis that they need to perform is beyond the materials covered in the course, and that they should therefore consult a statistician.

Assessment: CWA: 70% Module Test: 30%

Details of CWA: Two reports on statistical analyses: CW1 (30%) started in week 5 and due before the lecture in week 8; CW2 (40%) started in week 8 and due at the end of week 10.

Recommended texts and other learning resources:
Fowler Cohen and Jarvis: Practical Statistics for Field Biology (Wks 1-4, 6 only)
Howell: Statistical methods for psychology

2012-13

MODULE NUMBER: BIOL 431	MODULE TITLE: TOXICOLOGICAL MECHANISMS AND MEASUREMENTS		
Number of weeks: 5	*Term taught*: M1	*Contact hours*: 30	*Learning hours: 150*
Pre-requisites:		*Co-requisites*:	*Credits: 15*
Module organiser: Dr FL Martin		*Other lecturers*:	

***Aims and scope*:** *This module considers the underlying principals of toxicology, and the diverse applications of toxicology from mechanistic considerations to hazard assessment.*

Syllabus **Possible maximum of 15 students**

Lecture	**Title**	**Lecturer**
	Introduction to Toxicology	FLM
1	Adverse effects: principals of toxicology	
2	Adverse effects: mechanisms of toxicology	
	Xenobiotic/Drug design: relevance	
3	Hazard assessment and *in vitro* regulatory toxicology	
4	Cytogenetic endpoints in *in vitro* regulatory toxicology	
5	Risk characterisation in *in vivo* regulatory toxicology	
	Bio-distribution and elimination	
6	Disposition: absorption and distribution	
7	Disposition: phase I biotransformation	
8	Disposition: phase II biotransformation	
9	Environmental cancer causation	
10	Metabolic activation of xenobiotics	
	Classes of chemicals that cause cancer	

Practical/ Workshop	**Title**	**Lecturer**
Workshop 1.	Classification and examination of toxicological effects: choose and examine a particular adverse effect	FLM
Workshop 2.	Bacterial mutagenicity assays: concept and use	
Practical 3.	Preparation of a clonogenic assay: testing of positive controls	
Practical 4.	Good laboratory practise: scoring clonogenic assay and written report	

***Learning Outcomes*:**
On completion of this module students should be able to:

Generic

- Appreciate the underlying principals of toxicology i.e. the adverse effects of chemicals of living organisms
- Appreciate the diverse applications of toxicology from mechanistic considerations to hazard assessment
- A strong understanding of the fundamental principals of, and the practical skills required for, state-of-the-art methodologies routinely employed in environmental bio-monitoring and hazard assessment

Subject Specific

- Identify the three main categories of toxicology and how they inter-connect
- Explain the main underlying principles of *in vitro*/*in vivo* regulatory toxicology and possess a practical working knowledge of important state-of-the-art assays
- A strong understanding of toxicokinetics and toxicodynamics with particular emphasis on biotransformation and xenobiotic actions/interactions
- Appreciate the diverse mechanisms by which different agents may play an important role in cancer causation alongside epidemiological evidence
- Competence in the practical skills required in routine laboratory techniques used in environmental bio-monitoring and hazard assessment

Assessment: CWA: 50% **Exam: 50%**

Details of CWA:

1. Written piece of coursework (2,000 word essay delineating a toxic mechanism)

***Recommended texts and other learning resources*:**

1) Casarett & Doull's Toxicology: the basic science of poisons, edited by Curtis D. Klassen, 6th edition (published by McGrawHill)
2) Molecular Toxicology, edited by P. David Josephy and Bengt Mannervik, 2nd edition (publ by OUP)
3) The academic journals *Mutagenesis*, *Carcinogenesis*, *Environmental Science and Technology*, and *Environmental Health Perspectives* – all available online

MODULE NUMBER: BIOL 432	**MODULE TITLE: CONSEQUENCES OF TOXICOLOGICAL EFFECTS**		
Number of weeks: 5	*Term taught*: M2	*Contact hours*: 30	*Learning hours:150*
Pre-requisites: BIOL431		*Co-requisites*:	*Credits:15*
***Module organiser*:** Dr FL Martin		***Other lecturers*:**	

***Aims and scope*:** This module considers the underlying principals of toxicology, and the human health effects of various environmental exposures.

Syllabus

Lecture	**Title**	**Lecturer**
	Environmental exposures	FLM
1	Pesticides: classes and uses	
2	Routes of exposure and toxic effects I	
3	Routes of exposure and toxic effects II	
	Environmental monitoring	
4	Air pollution: risks and monitoring	
5	Toxic effects of air pollutants	
6	Adverse effects: applications of toxicology	
	Consequences of Environmental Exposure	
7	Relevance of epigenetic mechanisms in carcinogenesis	
8	Repair of carcinogen-induced damage	
9	Initiation/promotion/cancer development	
10	Epidemiological observations regarding cancer incidence	

Practical/ Workshop	**Title**	**Lecturer**
Workshop 1.	The need for cytogenetic assays in the pipeline	FLM
Practical 2.	Measurement of DNA damage induction in the alkaline single cell-gel electrophoresis ('comet') assay or micronucleus assay	
Practical 3.	DNA data analysis and graphical presentation with statistical considerations - written report	
Workshop 4.	Insights into adverse health effects: IR microspectroscopy as a novel technique	

***Learning Outcomes*:**
On completion of this module students should be able to:

Generic	*Subject Specific*
• Appreciate the underlying principals of toxicology i.e. the adverse effects of chemicals of living organisms • Appreciate the human health effects of various environmental exposures in terms of biotransformation, induction of somatic mutations, neurological impairments, epidemiology etc • A strong understanding of the fundamental principals of, and the practical skills required for, state-of-the-art methodologies routinely employed in environmental bio-monitoring and hazard assessment	• Identify the three main categories of toxicology and how they inter-connect • Appreciate the diverse mechanisms by which different agents may play an important role in cancer causation alongside epidemiological evidence • Describe the mechanisms by which different pesticides exert their adverse effects • Describe the different potential adverse effects of air pollution (accidental *Vs.* ''fence-line'' exposures) in the context of the various classes of such contaminants • Competence in the practical skills required in routine laboratory techniques used in environmental bio-monitoring and hazard assessment

Assessment: CWA: 50% Exam: 50%

Details of CWA:
1 written practical report

***Recommended texts and other learning resources*:**
1) Casarett & Doull's Toxicology: the basic science of poisons, edited by Curtis D. Klassen, 6th edition (published by McGrawHill)
2) Molecular Toxicology, edited by P. David Josephy and Bengt Mannervik, 2nd edition (published by OUP)
3) The academic journals *Mutagenesis*, *Carcinogenesis*, *Environmental Science and Technology*, and *Environmental Health Perspectives* – all available online

MODULE NUMBER: ECOL413	**MODULE TITLE: USING THE NATIONAL VEGETATION CLASSIFICATION**		
Number of weeks: 1	*Term taught*: Summer	*Contact hours*: 34	*Learning Hours 150*
Pre-requisites:		*Co-requisites*:	*Credits: 15*
***Module organiser*:** Dr Carly Stevens		***Other lecturers*:** TBC	

***Aims and scope*:** This module aims to provide a thorough grounding in the principles and practice of the vegetation survey including plant species identification, Phase 1 Survey and National Vegetation Classification (NVC). The module will consider the use of NVC for the description and understanding of plant communities and its application for vegetation survey, assessment and monitoring. The module is taught intensively within one week.

Syllabus

Lecture/ workshop	**Title**	**Lecturer**
	Plant species identification – Using vegetation keys to identify plant species. **Phase 1 habitat survey** – conducting phase 1 habitat surveys and mapping vegetation types **Introduction to the National Vegetation Classification** – An outline of the origin and purpose of the NVC as a systematic and comprehensive survey of the plant communities of natural, semi-natural and major artificial habitats in Britain. **The NVC survey methodology** – Basic technique of recognising boundaries and homogeneous strands, of locating sample quadrats and recording essential features of the composition and structure of the vegetation and its relationship to the habitat. **Using keys to identify plant communities** – Assembling field data into floristic tables, understanding the concepts of frequency and abundance to identify plant communities encountered in the field. **Understanding floristic tables of vegetation data** – Using these results to understand the basic style of phytosociological floristic tables; the concepts of communities and sub-communities; constant, associate, differential and preferential species. **Applications of the NVC for vegetation monitoring and management** - Using the data and results from the above in case studies to demonstrate descriptive and predictive applications of the NVC for vegetation monitoring, management and landscape design.	CS
Practical		**Lecturer**
	Several of the above sessions include practical field exercises involving data collection from a range of vegetation types with subsequent analysis, evaluation and interpretation.	CS

***Learning Outcomes*:**
On completion of this module a student should be able to:

1. Plan and execute a vegetation survey of a site
2. Identify a range of plant communities
3. Appreciate the complex relationships between vegetation and climate, soils and human impacts
4. Assess vegetation in local, regional and national contexts
5. Understand the potential and limitations of the NVC as a monitoring, management and design tool

Assessment*:* **CWA*:*** ***100%***

Details of CWA:
The coursework task is to assess the meaning and quality of supplied data about a site and its vegetation using the taught skills in the National Vegetation Classification

***Recommended texts and other learning resources*:**
Rose, F. (2006) The Wild Flower Key. Frederick Warne/Penguin
Rodwell, J.S. (1991 et seq). *British Plant Communities*, volumes 1-5. Cambridge University Press.
Rodwell, J.S. (2006). *National Vegetation Classification Users' Handbook*. Joint Nature Conservation Committee.

MODULE NUMBER: ECOL 414		MODULE TITLE: HABITAT MANAGEMENT	
Number of weeks: 5	*Term taught*: L2	*Contact hours*: 26	*Learning hours*: 150
Pre-requisites:	*Co-requisites*:		Credits: 15
Module organiser: Dr Andy Wilby	***Other lecturers***: External Lecturers		

Aims and scope:
On this course students will be shown how habitats can be managed for nature conservation through manipulation of species, communities and ecosystems,. This will include guidance in the construction of conservation management plans, in which conservation aims are specified, threats identified, and management actions defined, taking into account the dynamic nature of ecosystems and conflicts of interest in land use. The course is largely taught by external lecturers who are directly involved in the application of ecological principles to practical problems.

Syllabus

Lecture	***Title***	
	Topics will vary from year to year, according to availability of personnel etc. It is anticipated that topics will include: Dr A. Wilby – Introduction. Habitat management planning Dr A. Wilby – Ecological principles underlying management Dr F.W. Grayson – Grazing and grassland management Mr Richard Rhodes – Upland farming and wildlife RSPB staff – Conservation of birds and wetland habitats Game and Wildlife Conservation Trust staff – Integrating farming and wildlife conservation	
Excursions	*There will be 3 excursions, in separate weeks, to sites of conservation interest, led by the external contributors and AW.*	
Workshops	1. Site assessment and management planning 2. Ecological theory and its utility in management planning	AW

***Learning Outcomes*:**

Generic Outcomes - Students should develop skills in:	*Specific Outcomes - On completion of the modules student should be able to:*
• scientific writing • identifying, abstracting and synthesising pertinent information, whilst handling complexity and uncertainty appropriately	• discuss the principles underlying the management of habitats for conservation • describe how those principles can be applied in specific areas • construct a conservation action plan for a species or site

Assessment: **CWA** ***50%*** **Exam*:*** ***50%***

Details of CWA:
Students will write a conservation management plan based around one of the site visits.

Recommended Reading
Alexander M. (2008) Management planning for Nature Conservation: a theoretical basis and practical guide.
Sutherland, W.J. & Hill, D.A. (1995) Managing habitats for conservation
Sutherland, W.J. (2000) The conservation handbook: research, management and policy

MODULE NUMBER: ECOL 415	MODULE TITLE: CONSERVATION BIOLOGY		
Number of weeks: 5	*Term taught*: L1	*Contact hours*: 30	*Learning hours*: 150
Pre-requisites: -	*Co-requisites*: -		Credits: 15
Module organiser: Dr. Andy Wilby	***Other lecturers***: see below		

***Aims and scope*:** Conservation of biodiversity is a major goal of humanity, yet justifications for conservation are multifaceted and their relative importance varies among people and societies. Conservation objectives may also come into conflict with economic activity and development. While providing a grounding in the science of biological conservation, this module focuses on some of the key current challenges in conservation biology, where conservation objectives may trade-off against other human objectives. The module highlights our emerging understanding of the complex relationships between biodiversity conservation, the health of ecosystems and human well being. A <u>provisional</u> module outline follows:

Lecture	*Title*
1	Current status of biodiversity and ecosystem services. *A. Wilby*
2	Wild meat - the impact of hunting on biodiversity. *Luke Parry*
3-4	Managing fisheries – a local perspective on shell fish harvesting in Morecambe bay. *Inshore Fisheries and Conservation Authority*
5	Land sparing or wildlife friendly farming? *Jos Barlow*
6-7	Predator Control in Conservation. *Game and Wildlife Conservation Trust*
8	Biodiversity and human wellbeing. *A. Wilby*
9	Pollutants and biotic response in aquatic systems. *Ben Surridge*
10	The use of technology in species conservation. *Ian Marshall*
Seminars	Each lecture will be followed by a 50 minute workshop/discussion based on selected readings. Two additional student-led session will cover cross-cutting issues in conservation biology
Excursions	Two field excursions to Morecambe Bay and the Forest of Bowland will be linked to lectures 3-4 and 6-7.

***Learning Outcomes*:**

Generic Outcomes:

1. On successful completion of the module students will be able to:
2. Demonstrate an ability understand and integrate inter-disciplinary information
3. Develop skills of written critique of primary literature from the sciences and social sciences
4. Verbally express informed opinion of conservation issues

Specific Outcomes:

On completion of this module a student should be able to:

1. Demonstrate a broad understanding of how humanity benefits from ecosystem services and the primary justifications from conserving biodiversity
2. To discuss in detail several case studies where conservation comes into conflict with other economic and social objectives.
3. To discuss the challenge of conserving biodiversity while meeting the world's growing demand for food.
4. To display a deep understanding how the developing world will meet the dual challenges of economic development and biodiversity conservation

Assessment: CWA 50% Exam: 50%

Details of CWA:

Students will complete a critical review of the major challenges facing conservation biology in the 21st Century

Recommended Reading

MacDonald D and Service K (2007) Key topics in Conservation Biology. Blackwell

Sodhi NS & Ehrlich PR (2010) Conservation Biology for All. Oxford University Press

Millennium Ecosystem Assessment (2005) Millennium Ecosystem Assessment Synthesis Report, <u>www.millenniumecosystemassessment.org</u>

Sala O, Meyerson LA & Parmesan C (2009) Biodiversity change and human health: from ecosystem services to spread of diseases. Island Press, Washington DC

MODULE NUMBER: ECOL 418		**MODULE TITLE: WILDLIFE POPULATION ECOLOGY**	
Number of weeks: 5	*Term taught*: M2	*Contact hours*: 35	*Learning hours*: 150
Pre-requisites: Some elementary mathematics, e.g. O level maths, or equivalent		*Co-requisites*: None	Credits: 15
Module organiser: Stuart Sharp		*Other lecturers*: none	

Aims and scope: The aim of this module is to provide students with knowledge of population processes within wildlife ecology. The module takes a step-by-step approach to understanding wildlife population ecology, from the basics up to more complex interactions between species. The practical element of the module includes field, laboratory and modelling assignments. After taking this module, students will appreciate the factors that contribute to population change, be able to construct life tables from birth and death data, and be able to apply quantitative models of population ecology to applied situations. Knowledge of these processes is vital for people working in the fields of conservation or management of natural resources, such as harvesting of fish stocks, infectious disease control, and pest management, examples of which are scattered throughout the module. The module will demonstrate how population processes influence the behaviour of individual animals, populations of individuals, and communities of populations, so showing the importance of wildlife population ecology at all levels.

Syllabus

Lecture	*Title*	*Lecturer*
1	*Introduction: what is wildlife population ecology and how do we study it?*	SS
2	*Population growth: from water fleas to blue whales*	SS
3	*Life tables I: quantifying survival and death rate - humans, sheep and fruit flies*	SS
4	*Life tables II: quantifying reproduction and birth rate - mussels, moose and mice*	SS
5	*Density-dependence I: scramble and contest competition - from beetles to grouse*	SS
6	*Density-dependence II: intra-specific competition and the route to chaos*	SS
7	*Interactions between species I: inter-specific competition - a tail of two squirrels*	SS
8	*Interactions between species II: predator-prey interactions - the lynx and the hare*	SS
9	*Pests, parasites and pathogens I: biological control, parasitoids and rats*	SS
10	*Pests, parasites and pathogens II:: rabies, foot-and-mouth and nematode worms*	SS

Practical/ workshop	*Title*	*Lecturer*
1	Collecting population data: small mammal trapping in the field	SS
2	Mark-release-recapture methods: laboratory practical	SS
3	Constructing life tables: data collection in the field and *Excel* practical	SS
4	Population modelling: computer simulation practical using *Populus*	SS
5	Case studies in applied population ecology; poster presentation and workshop	SS

***Learning outcomes*:**

On completion of this module a student will be able to:

Generic

- appreciate how individual life history decisions determine population level processes
- use quantitative methods and population modelling packages
- resolve applied ecological problems using basic biological information
- summarize complex data using a variety of methods

Specific

- demonstrate a knowledge of basic population concepts, such as density-dependence, trade-offs, competition, predation, parasitism, etc.
- generate a life table using demographic (birth and death) data.
- demonstrate a knowledge of the fundamentals of population models, such as the Logistic and Lotka-Voltera models, and appreciate the use of population models in applied ecology

Assessment*: *Cwa: 50% Exam: 50%

Details of cwa:

The module will be assessed through CWA with respect to the following outputs:

- A poster synthesising a quantitative aspect of wildlife population ecology, demonstrating an ability to use disperate literature sources and to present a coherent story of applied or theoretical interest.

The module will be assessed through examination with respect to the following learning outcomes.

- Appreciate how individual life history decisions determine population level processes.
- Understand the value of quantitative methods and mathematical modelling for making applied management decisions.

Recommended texts and other learning resources:

- Begon, M., Harper, J.L. & Townsend, C.R. (1996) Ecology, 3rd edition, Blackwell Science.
- Ricklefs, R.E. & Miller, G.L. (2000) Ecology, 4th edition, W.H. Freeman & Co.
- Krebs, C.J. (2001) Ecology. 5th edition. Benjamin Cummings, San Francisco.

MODULE NUMBER: ECOL419		MODULE TITLE: WILDLIFE MONITORING TECHNIQUES	
Number of weeks: 5	*Term taught: M1*	*Contact hours: 38*	*Learning hours: 150*
Pre-requisites: None		*Co-requisites: None*	*Credits: 15*
Module organiser: Dr Rosa Menendez		***Other lecturers:*** Dr Jos Barlow, Dr. Ian Hartley, Dr Andy Wilby, Dr Ken Wilson,	

Aims and scope:
The module will teach a range of taxonomically-based field skills that will combine identification, sampling and other methods used to quantitatively monitor or assess populations. Components will include sessions on birds, mammals and invertebrates.

Syllabus

	Title	**Lecturer**
	The module will have five sections, each delivered with one or two lectures and including a field component in campus or away. Section content will be determined by staff skills and may vary from year to year in relation to availability, but examples of key components include:	
	a) Bird census techniques. Identification of key groups, such as waders or woodland birds using plumage and song.	IH
	b) Mammal census techniques. Small mammal trapping and marking, issues of sample bias, camera traps, indirect methods.	KW
	c) Terrestrial Invertebrate sampling methods. Identification of key taxa to various levels of detail, trapping methods (e.g. pitfall, sweep netting, suction sampling).	RM/AW
	d) Woodland sampling techniques. Measuring woodland structural complexity.	JB
	e) Measuring and representing species diversity (computer based session using EstimateS software).	RM/AW

***Learning outcomes*:**

On completion of this module a student will be able to:

- Demonstrate identification skills with the key taxa used on the module
- Identify appropriate sampling methods and apply them in the field
- Demonstrate a knowledge of the fundamentals of sampling bias for different trapping, recording and sampling methods
- Demonstrate how surveys are used at different scales

Assessment: CWA: 100%

Details of CWA:

1) A report on a survey of two taxa (3000 words) (80%)

2) Module test (20%)

Recommended texts and other learning resources:

Bibby, C.J., Burgess, N.D., & Hill, D.A. (1992) Bird Census Techniques Academic Press, London
Sutherland, W.J., ed. (2006) Ecological Census Techniques: a handbook. Cambridge University Press, Cambridge
Southwood, T.R.E. (2000) Ecological Methods, Third edition. Blackwell Science, Oxford

MODULE NUMBER: ENV.404	Module title: **Flood Forecasting and Flood Risk Management**		
Number of weeks: 5	*Term taught*: *L2*	*Contact hours*: 30	*Learning hours*: 150
Pre-requisites: -300 level hydrology module	*Co-requisites*:		
Module organiser: Prof Keith Beven	*Other lecturers*: - Guest speakers TBA		

Aims and scope: To develop the understanding needed in flood risk assessment, flood frequency analysis, flood forecasting and warning, and catchment flood management plans. To apply this understanding to develop a flood risk map.

Syllabus

Lecture	*Title*	*Lecturer*
	2 Lecture sessions, one seminar session, one practical exercise / computer lab / presentations each week	*KJB and Guest Lecturers*
	Session 1: Introduction to flood risk management: Historical context / Definitions of flood risk / Flood Frequency / Flood Inundation Mapping / Flood Routing / Real-Time Flood Forecasting & Warning / Flood Defence / Flood Management	
	Session 2: Flood Frequency 1: Distributions	
	Session 3: Flood Frequency 2: Flood Estimation Handbook	
	Session 4: Flood Frequency 3: Continuous Simulation	
	Session 5: Flood Routing and Risk Mapping: Theory of Channel Flow	
	Session 6: Flood Routing: Model Calibration and Uncertainty	
	Session 7: Real-time flood forecasting and flood warning	
	Session 8: Flood defence strategies and reliability analysis	
	Session 9: Catchment Flood Management Plans	
	Session 10: Planning for Climate Change	
Practical/ Workshop	*Title*	*Lecturer*
	Designing instrument network for a flood forecasting system	*KJB/GuestKJB*
	Flood Forecasting in the River Eden: the Carlisle Flood 2005	

Learning Outcomes:
On completion of this module a student will be able to:

Generic Outcomes

- To develop understanding of frequency concepts and prediction uncertainties. To develop discussion and presentation skills.

Subject Specific Outcomes

- To develop the understanding needed in flood risk assessment, flood frequency analysis, flood forecasting and warning, and catchment flood management plans.
- To apply this understanding to develop a flood monitoring and forecasting programme.
- To develop knowledge and report on a specific area of flood risk management

Assessment*:* **CWA*: 100%***

Details of CWA: Each student will prepare a seminar presentation and report on a specific topic in flood risk assessment.

Recommended texts and other learning resources:

Beven, K J, Rainfall-runoff modelling – the primer, Wiley, 2003

Beven, K J, *Environmental Modelling: An Uncertain Future?,* Routledge, 2009

Blazkova, S and Beven, K J, 2004, Flood frequency estimation by continuous simulation of subcatchment rainfalls and discharges with the aim of improving dam safety assessment in a large basin in the Czech Republic, *J. Hydrology*, 292, 153-172

Romanowicz, R, Young, P C and Beven, K J, 2006, Data assimilation and adaptive forecasting of water levels in the River Severn catchment, UK, *Water Resour. Res.*, 42, W06407, doi:10.1029/2005WR004373

Romanowicz, RJ, Young, PC, Beven, KJ and Pappenberger, F, 2008, A Data Based Mechanistic Approach to Nonlinear Flood Routing and Adaptive Flood Level Forecasting, *Advances in Water Resources*, 31:1048–1056

Pappenberger, F., Beven, K.J., Frodsham, K., Romanovicz, R. and Matgen, P., 2006. Grasping the unavoidable subjectivity in calibration of flood inundation models: a vulnerability weighted approach. *Journal of Hydrology*, 333, 275-287

Faulkner, H, Parker, D, Green, C, Beven, K, 2007, Developing a translational discourse to communicate uncertainty in flood risk between science and the practitioner, *Ambio*, 16(7), 692-703

Wilby, RL, Beven, KJ and Reynolds, N, 2008, Climate change and fluvial flood risk in the UK: More of the same?, *Hydrol. Process.*,22(14): 2511-2523.

MODULE NUMBER: ENV 405	MODULE TITLE: GROUNDWATER RESOURCES AND PROTECTION		
Number of weeks: 5	*Term taught*: M2	*Contact hours*: 24	*Learning hours*: 150
Pre-requisites: Some basic hydrology	*Co-requisites*:		*Credits: 15*
Module organiser: Prof. A Binley	***Other lecturers***: Jan Hookey (Environment Agency)		

Aims and scope: This course aims to introduce the principles of groundwater flow and transport and describe the various approaches for investigating groundwater systems. Challenges facing management of groundwater quantity and quality are outlined. Use is made of computer models to solve practical problems relevant to the water industry.

Syllabus

Lecture	*Title*	*Lecturer*
1	Groundwater fundamentals	AB
2	Aquifer properties	AB
3	Groundwater investigation techniques	AB
4	Groundwater flow	AB
5	Well hydraulics	AB
6	Groundwater flow models	AB
7	Natural groundwater quality	AB
8	Groundwater transport	AB
9	Groundwater transport models	AB
10	Managing groundwater resources	JH
11	Groundwater pollution remediation and protection	JH
Practical/ workshop	***Title***	***Lecturer***
P1	Groundwater investigation techniques: field visit	AB
P2	Modelling groundwater flow using ASMWIN	AB
P3	Modelling groundwater transport using ASMWIN	AB
P4	Student presentations	AB

Learning Outcomes:
On completion of this module a student will be able to:

Generic Outcomes
- Numerically evaluate model results
- Prepare reports for a Head of Section as if working for an organisation such as the Environment Agency

Subject Specific Outcomes
- List the methods that are widely used for investigating groundwater systems.
- List the main steps in conducting a pumping test for determination of aquifer formation constants.
- Apply a specific groundwater model (ASMWIN) to a number of problems.
- State the limitations of models, such as ASMWIN, for practical use.
- Determine values of subsurface flow parameters from experimental data
- List a range of approaches for protecting and managing groundwater resources.

This will be achieved through lectures and hands-on practical training with a variety of models.

Assessment: ***CWA: 50%*** ***Exam: 50%***

Details of CWA:
One report (40% total assessment) based on the practical exercises.
One short presentation (10% total assessment).

Recommended texts and other learning resources:
Schwartz, F.W., and H. Zhang, 2002,, *Fundamentals of Ground Water*, Wiley.
Fetter, C.W., 2001,*Applied Hydrogeology*, Prentice-Hall
Domenico, P.A. and F.W., 1998, Schwartz, *Physical and Chemical Hydrogeology*, Wiley
Hiscock, K, 2007, *Hydrogeology principles and practise*, Blackwell
Younger, P, 2007, *Groundwater in the Environment*, Blackwell
The UK Groundwater Forum (http://www.groundwateruk.org/)

MODULE NUMBER: ENV.407	MODULE TITLE: CATCHMENT PROTECTION		
Number of weeks: 1	*Term taught*: Lent Vacation Wk 1	*Contact hours*: 5 full days field and laboratory based teaching	*Learning hours*: 150
Pre-requisites: undergraduate or masters experience in hydrological/chemical/biological sciences, e.g. LEC435		*Co-requisites*:	Credits: 15
Module organiser: Dr Ben Surridge		*Other lecturers*:	

Aims and scope:
Catchments are increasingly perceived as complex and highly interconnected systems. This presents significant difficulties for those who manage catchments, but also a range of novel and timely research opportunities. In this context, the module aims to provide students with understanding and practical experience of key research and management challenges facing the future management of catchments. The module will take the Eden catchment as a case study, and draw on the latest land and water management framework, derived from the Water Framework Directive, as a basis for discussion. After analysing this framework and identifying significant challenges, students will use a combination of field, laboratory and data analysis techniques to investigate research questions related to biophysical processes within catchments. These investigations will lead to an appreciation of the limits to current knowledge and the opportunities for future research.

Limited places, with priority given to students on the full- or part-time MSc Sustainable Water Management.

Syllabus

The module will be run as a series of linked project days. The content of the week will provide students with experience of:

- The Water Framework Directive, River Basin Management, and the Eden catchment
- Water resources management and river flow
- Pollutant sources, pathways and impacts in receiving waters
- Assessing morphological conditions in rivers
- Links between land use and sustainable water management
- Interaction with Environment Agency/Water Company/Rivers Trust staff

Learning Outcomes:
On completion of this module a student will be able to:

- analyse management frameworks relevant to sustainable water management, and identify and justify linked research and management challenges that emerge from these frameworks
- apply relevant field, laboratory and data analysis techniques to investigate these challenges, and describe the limitations and potential sources of error in these techniques
- critically appraise the current state of knowledge related to these challenges, and plan and justify future research activities to address gaps in knowledge

Assessment: **CWA*: 100%***

Details of CWA:
A structured report ('workbook') with components for the individual project days, site visits, and integrating catchment research and management question

Recommended texts and other learning resources:
Students will be directed towards specific reading during each project day. Useful background material in the general context of the Water Framework Directive and sustainable water management includes:

Moss, B. (2008) The Water Framework Directive: Total environment or political compromise? *Science of the Total Environment*, 400, 32-41.

Carter, J. (2007) Spatial planning, water and the Water Framework Directive: insights from theory and practice. *The Geographical Journal*, 173, 330-342.

UKTAG Recommendations on Surface Water Classification Schemes, particularly section 1. Available from: http://www.wfduk.org/UKCLASSPUB/LibraryPublicDocs/sw_status_classification

UKTAG Phase 1 and Phase 2 reports on UK Environmental Standards and Conditions. Available from: http://www.wfduk.org/UK_Environmental_Standards/

Harris, G. (2002) Integrated assessment and modelling: an essential way of doing science. *Environmental Modelling and Software*, 17, 201-207.

Kinzig, A.P. (2001) Bridging disciplinary divides to address environmental and intellectual challenges. *Ecosystems*, 4, 709-715.

MODULE NUMBER: ENV.408	MODULE TITLE: MODELLING ENVIRONMENTAL PROCESSES		
Number of weeks: 5	*Term taught*: L1	*Contact hours*: 30	*Learning hours*: 150
Pre-requisites: None		*Co-requisites*:	*Credits:* 15
***Module organiser*:** Dr W Tych		***Other lecturers*:** None	

***Aims and scope*:** Introduction to basic principles and approaches to computer-aided modelling of environmental processes with applications to real environmental problems such as pollutant dispersal in rivers and estuaries, population dynamics etc. The mathematical and statistical aspects of modelling and data analysis are kept to a minimum and the emphasis is on the use of computer-based methods and practical examples.

Syllabus

Lecture	**Title**	**Lecturer**
1-3	Scope of the course; Scientific methodology and modelling: Introduction to modelling;	WT
4-6	Approaches to modelling: the role of data and perceptions in the modelling process; the problems of badly defined systems in the context of modelling environmental processes	
7-10	The concept of dynamic system. First order linear systems, with the Nicholson blowfly dynamics and the Aggregated Dead Zone (ADZ) model of dispersion in a river used as practical case studies. Transfer function models, steady state gain and time constant; serial, parallel and feedback connections of first order systems. Block diagram analysis.	
11-15	Muskingum-Cunge, Lag and Route, and General Transfer Function models of flow in a river system Second order linear systems with the predator-prey equations and a climate model as practical examples; natural frequency and damping ratio; higher order systems Linear vs. Nonlinear systems – basic introduction Throughout the course case studies will be used to illustrate the material.	

Pract/ workshp	**Title**	**Lecturer**
1	Blowfly population modelling and simulation (Matlab/Simulink package)	WT & demonstrators
2	Aggregated Dead Zone (ADZ) modelling (Matlab/Simulink package)	
3	Predator-Prey population dynamics modelling and Gilliland Climate model	
4	Modelling river flow	

***Learning Outcomes*:**
On completion of this module students should be able to:

Generic	*Subject*
• Communicate with mathematicians and numerical analysts in joint projects involving modelling. • Understand the way in which simple mathematical concepts can be used to build models of environmental systems • Be able to individually undertake some simple modelling tasks and to analyse experimental data.	• Evaluate the principles and problems of computer aided modelling of environmental systems. • Use contemporary industry standard numerical software to analyse and simulate environmental systems.

Assessment: CWA: 50% Exam: 50%

Details of CWA:
Coursework assessment is based on practical reports. During the practical computer based sessions the students are guided through specific data analysis tasks closely related to the lecture contents

***Recommended texts* and other learning resources*:**
There are no recommended books since all available literature is designed for more specialist audiences. However the following texts can be useful to the course if read with discretion.

Young, P.C. (1993) Concise Encyclopaedia of Environmental Systems. Pergamon: Oxford (selected articles)*
Young, P.C., Parkinson, S. and Lees, M.J. (1996) Simplicity out of complexity: Occam's Razor revisited* Journal of Applied Statistics, 23, 165-210
Young, P.C. Recursive Estimation and Time Series Analysis. An Introduction, Springer, 1984
Bennett, R.J., Chorley, R.J. Environmental Systems, Philosophy, Analysis and Control, Methuen 1980*
Hardisty, J. et al. Computerised Environmental Modelling, A practical introduction using Excel, Wiley, 1993

MODULE NUMBER: ENV.412	MODULE TITLE: ENVIRONMENTAL RADIOACTIVITY		
Number of weeks: 5	*Term taught*: M2	*Contact hours*: 20	*Learning hours*: 150
Pre-requisites:	*Co-requisites*:		*Credits: 15*
***Module organiser*:** Dr J. Pates	***Other lecturers*:** none		

***Aims and scope*:** The aim is to provide an understanding of the origin and behaviour of natural and artificial radionuclides in the environment. Their detrimental consequences as pollutants for human health and the environment are discussed, as well as the relevant legislation controlling exposure.

Syllabus

Lecture	**Title**	**Lecturer**
1	Introduction to radioactivity.	Dr Jackie Pates
2	Radioactive decay and ingrowth.	
3	Interactions of radiation with matter.	
4	Human radiation dose & detriment.	
5	The effects of ionising radiation.	
6	Radiation protection in the UK.	
7	Sources of radioactivity in the environment.	
8	The nuclear fuel cycle.	
9	Nuclear waste management.	
10-11	Behaviour of radioactive contaminants in the marine environment	
12	Case study: Tc-99 in the Irish Sea	
13-14	Behaviour of radioactive contaminants in the terrestrial environment	
15	Case study: the Chernobyl accident	

Practical/ Workshop	**Title**	**Lecturer**
Workshops 1-3.	Calculation methods workshops.	Dr Jackie Pates
Practical 1.	Radioactive decay and ingrowth.	Dr Jackie Pates
Practical 2.	Radiation dose estimation.	
Practical 3.	Radon in homes.	
Seminars 1-4:	Impact of radiation on the environment.	

***Learning Outcomes*:**
On completion of this module students should be able to:

Generic	*Subject Specific*
• Manipulate and solve basic radioactive decay law equations. • Use a range of standard resources (e.g. Web of Knowledge) to research a problem. • Prepare reports for different audiences (popular science, review paper).	• Identify the sources of natural and artificial radioactivity in the environment. • Explain the main processes by which radionuclides are distributed through the environment. • Apply the principles of dose assessment to determine the impact of environmental exposure to radioactivity.

Assessment: CWA: 50% Exam: 50%

Details of CWA:
Review paper (40%), short 'New Scientist' style article (10%)

***Recommended texts and other learning resources*:**
Cooper, J.R. et al. (2003) Radioactive Releases in the Environment: Impact and Assessment. John Wiley (DUHSQ)
Eisenbud, M. and Gesell, T. (1997) Environmental Radioactivity. 4th ed. Academic Press (DUHSQ)
Hughes, J.S. (1999) Ionising Radiation Exposure to the UK Population. (DUHSQ oversize)
Sumner, D. et al. (1994) Radiation Risks. 3rd ed. Tarrogon (DUHSQ)

MODULE NUMBER: ENV.431	MODULE TITLE: POLLUTION MICROBIOLOGY		
Number of weeks: 5	*Term taught*: M1	*Contact hours*:	*Learning hours:* 150
Pre-requisites: None	*Co-requisites*: None	*Credits:* 15	
***Module organiser*:** Prof K.T. Semple	***Other lecturers*:**		

***Aims and scope*:** The course content broadly encompasses the interactions between microorganisms and naturally occurring organic matter and how this relates to the degradation and persistence of environmental pollutants. The mechanisms of organic matter decomposition and pollutant degradation will be discussed in detail, with particular emphasis being placed in environmental systems, particularly that of soil. The course will then move towards the application of these processes in biological treatment of chemically contaminated ecosystems, highlighting the strengths and weaknesses of the processes, using case studies.

Syllabus

Lecture/workshop	**Title**	**Lecturer**
1	Introduction to environmental microorganisms	KTS
2	Discuss the decomposition of natural compounds	
3-4	Discuss catabolic processes: biodegradation, mineralisation, biotransformation, co-metabolism and detoxification.	
5-6	Relate the decomposition of natural compounds to biodegradation of organic compounds.	
7-11	Discuss pollutant degradation in the environment, highlighting interactions between pollutants and the abiotic and biotic environment and how this impacts on biodegradation. Discuss the concept of bioavailability.	
12-13	Discuss the microbial degradation of contaminants in both aerobic and anaerobic environments.	
14-15	Discuss bioremediation of contaminated systems stressing the involvement of microorganisms, focussing on bioremediation	

***Learning Outcomes*:**

After completion of the module, the students will be aware of the importance of microorganisms within different ecosystems, considering biotic interactions, nutrient cycling and organic matter turnover. Further, the students will be cognisant of the role of microorganisms in waste treatment systems, how microorganisms adapt to and metabolise man-made chemicals and their role in the assessment and remediation of contaminated land.

At a generic level, the students will be able to critically appraise aspects of the scientific literature, formulating robust scientific arguments. Further the students will gain experience in teamwork as well as planning, researching and implementing a group presentation.

Assessment: CWA: 50% Exam: 50%

Details of CWA:
Essay and Oral presentation

***Recommended texts and other learning resources*:**
Main Text:

R. Atlas and R. Bartha (1998) Microbial Ecology: Fundamentals and Applications, 3rd Edition, The Benjamin/Cummings Publishing Co.
M. Alexander (1994) Biodegradation and Bioremediation. Academic Press.
R.L. Crawford and D.L. Crawford (1996) Bioremediation: Principles and Applications. Cambridge University Press.
S. McEldowney, D.J. Hardman and S. Waite (1993) Pollution: Ecology & Biotreatment, Longman Scientific & Technical.

MODULE NUMBER: ENV.432	MODULE TITLE: CHEMICAL RISK ASSESSMENT		
Number of weeks: 5	*Term taught*: M2	*Contact hours*: 28	*Learning hours:* 150
Pre-requisites: None	*Co-requisites*: None	*Credits:* 15	
***Module organiser*:** Dr Crispin Halsall	***Other lecturers*:** External specialists from environmental consultancies		

***Aims and scope*:** This course will aim to give students grounding in the scientific process behind chemical risk analysis. The effect of chemicals in the environment will be introduced with concepts such as dose-response relationships and observed-effect levels, as well as examining modes of entry and routes of exposure to humans, biota and the ecosystem as a whole. A large part of the module will be dedicated to understanding quantitative exposure assessment, with the introduction of fate modelling and the prediction of concentrations in different environmental compartments. Students will also be introduced into current assessment procedures for pesticide/chemical registration and will partake in group practicals/workshops to understand the steps in chemical risk analysis.

Syllabus

Lecture	**Title**
	Hazard, risk and chemical safety.
	Chemical legislation & REACH.
	Generic risk assessment procedure.
	Hazard identification and assessment.
	Exposure assessment: modelling chemical transport and fate and an introduction to chemical fugacity.
	Risk characterisation: assessing carcinogenic and non-carcinogenic exposure.
	QSARs and chemical properties.
	Contamination risk of remote environments.
	Risk assessment for environmental management.
	Ecological risk assessment.
	Probabilistic approaches to risk assessment.

Practicals/ Workshops	**Title**
P1	GENEEC – basic screening model for pesticide fate in the environment.
P2	CalTOX – Assessing the risk posed by hexachlorobutadiene.
W1	Modelling organic chemical fate in the environment.

***Learning Outcomes*:**
On completion of this module students should be able to:

Generic	*Subject Specific*
• Gain experience with contemporary computer models detailing chemical fate and human/biota exposure primarily for organic chenical contaminants.	• Gain knowledge on current legislation (EU, UN and US) regarding chemical use and release.
• Understand weaknesses and uncertainty in chemical and environmental datasets and how these can shape the outcome of a risk assessment procedure.	• Perform a chemical risk assessment procedure to assess the risks posed by both carcinogenic and non-carcinogenic chemicals. • Learn the steps for quantitative exposure assessment for chemical transport and fate in the environment

Assessment: CWA: 50% Exam: 50%

Details of CWA
Write up of the GENEEC and CalTOX practical classes (2 pieces)

***Recommended texts and other learning resources*:**
Rodricks J. V. Calculated Risks (2nd Edition) Cambridge University Press (2006)
Asante-Duah, D. Kofi. Risk Assessment in Environmental Management. Wiley (1998)
Hester, R.E., Harrison R.M. Risk Assessment and Risk Management, Royal Soc. of Chem. (1998)
Mackay D. Multimedia environmental models: the fugacity approach. Lewis Publishers (2001)

MODULE NUMBER: ENV.434	MODULE TITLE: CONTAMINATED LAND AND REMEDIATION		
Number of weeks: 5	*Term taught*: L1	*Contact hours*: 27	*Learning hours:* 150
Pre-requisites:	*Co-requisites*:		*Credits:* 15
***Module organiser*:** Prof K.T. Semple	***Other lecturers*:**		

***Aims and scope*:** The module will provide students with a broad view of issues related to contaminated land in particular: (a) typical contamination problems; (b) methodologies for assessing the extent and seriousness of contamination; (c) applicability and effectiveness of remediation techniques as a function of contaminant and site conditions.

Syllabus

Lecture	**Title**	**Lecturer**
1.	Introduction to contaminated land issues.	KTS
2.-3.	Legislation on contaminated land.	
4-5.	Risk-based approaches to contaminated land assessment.	
6-7.	Fate and behaviour of contaminants in the environment	
8-10.	Remediation: general concepts.	
11-15.	Seminars.	

Practical/ workshop	**Title**	**Lecturer**
1.	Site visit	KTS
2.	Visiting speaker	
3.	Visiting speaker	
4.	Visiting speaker	

***Learning Outcomes*:**
After completion of the module, the students will be

- aware of the scale of contaminated land in the UK
- appraised of the changes in legislation pertaining to and the processes used to assess the risk associated with contaminated land
- able to scientifically discuss the processes which control the behaviour of chemicals in soil and comment on the processes which may affect remediation.
- able to communicate in an informed manner about methods of assessment and remediation of contaminated land.

At a generic level, the students will be able to critically appraise aspects of the scientific literature, formulating robust scientific arguments. Further the students will gain experience in teamwork as well as planning, researching and implementing a group presentation.

Assessment: CWA: 25% Presentation: 25% Exam: 50%

Details of CWA:
Group presentation and report. Sampling and remediation design case study.

***Recommended texts and other learning resources*:**

T. Carney(ed), 1998, Contaminated Land, Problems and Solutions, E&F Spon.
E.K. Nyer, 1992, Practical Techniques for Groundwater and Soil Remediation, CRC Press.
E.K. Nyer et al., 1996, In Situ Treatment Technology, CRC Press.
N. Wilson, 1995, Soil Water and Ground Water Sampling, CRC Press.
R. Atlas and R. Bartha (1993) Microbial Ecology: Fundamentals and Applications, 3rd Edition, The Benjamin/Cummings Publishing Co.
S. McEldowney, D.J. Hardman and S. Waite (1993) Pollution: Ecology & Biotreatment, Longman Scientific & Technical.
M. Alexander (1994) Biodegradation and Bioremediation, Academic Press.

MODULE NUMBER: ENV.435	MODULE TITLE: ENVIRONMENTAL TOXICOLOGY		
Number of weeks: 5	*Term taught*: L2	*Contact hours*: 28	*Learning hours:* 150
Pre-requisites: None	*Co-requisites*: None		*Credits:* 15
***Module organiser*:** Dr C Halsall	***Other lecturers*:** Scientists from CEH, Lancaster		

***Aims and scope*:** This course introduces students to aspects of xenobiotic chemicals in the environment; investigating exposure to and effects on biota and humans. Modes of chemical action accompanied by examples of chemical toxicity in the environment will also be covered, including tests and procedures used for regulatory purposes to assess the impact of chemical substances on different types of biota. This course will address chemical behaviour and availability with respect to organism exposure and associated biological responses. The deleterious effects of contaminants will be highlighted, including biomonitoring and bioassays to examine low dose, chronic exposure to chemicals.

Syllabus

Lecture/ Workshop	**Title**	**Lecturer**
	Introduction to toxicology. Metals and their health effects. Persistent organic pollutants and toxic equivalents. Accumulation of organic contaminants in food chains. Biotic transportation/transformation and toxic metabolites. Toxico-kinetics and dose response. Endocrine disruption. Biomonitoring and bioassays. Biochemical effects of toxicants.	CH
Practical/workshop	1. Drinking water quality and health. 2. Modelling the bioaccumulation of a persistent organic pollutant in fish. 3. Earthworm 'choice chamber' experiment. 4. Tour of CEH: meeting toxicologists at work.	

***Learning Outcomes*:**
On completion of this module students will be able to:

Generic	*Subject Specific*
• Develop presentation skills through preparation and delivery of a case study on Selected toxins present in the environment. • Understand how science-led toxicology research shapes regulatory policy concerning the setting of standards for chemical substances in food and water.	• Understand chemical toxicity and methods of assessing toxic responses, including dose-response, biomonitoring and bioassays. • Learn the routes by which chemicals enter biota and the biochemistry detailing biotic transformation and metabolism.

Assessment: CWA: 50% Exam: 50%

Details of CWA:
Oral presentation (30%) and practical write-up (70%).

***Recommended texts and other learning resources*:**
Walker et al. Principles of Ecotoxicology. Third Edition (2006)
Wright, D. A. & Welbourn, P. Environmental Toxicology (2002)
Walker G.H. et al Principles of Ecotoxicology (2006)
Yu, M.H. Environmental Toxicology (2001).

Module number: **ENV 441**	*Module title*: **GEOLOGICAL HAZARDS**		
Number of weeks: 5	*Term taught*: L1	*Contact hours*: 30	*Learning hours*: 150
Pre-requisites: None		*Co-requisites*: None	*Credits :* 15
Module organiser: Dr Mark W. Hounslow		*Other lecturers*: Dr Steve J. Lane, Dr. Emily Heath	

Aims and scope: This module is designed for students who wish to understand more about the fundamentals of geological hazards and the processes responsible. The module puts geological hazards in their context and primarily includes issues of prediction, but with linkage to response and preparedness issues. The core of the module addresses the fundamental processes and mechanics of hazard prediction. Specific hazards addressed are seismic-based hazards, slope stability and landslides and volcanic hazards (flank collapse, plumes and pyroclastic flows). It includes case histories of both national and international disasters.

Syllabus

	Title	*Lecturer*
Lecture		
1	Introduction. Earthquake locations and magnitudes	EH
2	Earthquake hazards and how faults rupture	EH
3	Earthquake prediction and forecasting	EH
4	Seismic risk mitigation and early warning systems	EH
5	Tsunami hazards	EH
6	Hazardous slopes and landslides	MH
7	Stress and strength of rocks and engineering soils	MH
8	Stress analysis in engineering soils and rocks	MH
9	Predicting landslides	MH
10	Scaling issues of Landslides: volcanoes and mountains	MH
11	The Volcanic hazard	SL
12	Volcano monitoring and forecasting	SL
13	Rheology of flows and flow runout 1	SL
14	Extreme events 1	SL
15	Extreme events 2	SL
Practical activities	1) Probabilistic forecasting of earthquakes	EH
	2) Landslide prediction and material properties	MH
	3) Hekla hazards	SL
	4) Fieldtrip to assess the Falls Foot landslide	SL/MH
Seminars	Seismic Hazards.	EH
	Stress and fracturing.	MH
	Slope transfer	SL
	Volcanic risk	SL

Learning outcomes:
On completion of this module students will be able to:

- Describe and explain the concepts and foundations of geological hazards
- Apply and report on the methods of prediction and mitigation strategies of geological hazards
- Apply simple principles of analysis of slope failure using a variety of natural hazard situations
- Demonstrate and elaborate an understanding of geological processes responsible for the occurrence, recurrence and magnitude of hazards.
- Apply simple prediction scenarios of geological hazard occurrence, using geological data sets.

Assessment: CWA*: 100%*

Details of CWA:
This is in two parts. The first involves a report on the Dales fieldwork (20%). The second is a consultancy-style report detailing critical assessment of a geological hazard specific to a single case study (80%).

Recommended texts and other learning resources:
Bell, F.G. (2003).'Geological hazards: their assessment, avoidance and mitigation'. Taylor & Francis.
Dowrick, D.J. (2003) 'Earthquake risk reduction', Wiley.
Highland, L.M., & Bobrowsky, P. (2008) 'The Landslide Handbook—A Guide to Understanding Landslides'. U.S. Geological Survey Circular 1325.
Kusky, T. M. (2003). Geological hazards: a sourcebook. Westport, Conn, Greenwood Press.
Murck, B.W. et al (1997) 'Dangerous Earth: an introduction to geologic hazards'. Wiley.

MODULE NUMBER: ENV 448	MODULE TITLE: DATA ANALYSIS AND PROGRAMMING SKILLS		
Number of weeks: 10	*Term taught*: S1 and S2	*Contact hours*: 60	*Learning hours:* 150
Pre-requisites: Basic numeracy (e.g. Excel), if required: ENV460	*Co-requisites*: none	*Credits*: 15	
Module organiser: Dr. Wlodek Tych	***Other lecturers***: Dr Arun Chotai		

Aims and scope: The course should provide the students with advanced scientific numeracy skills. The course focuses on data processing and visualisation for use with dissertation work. It includes introductory elements of Matlab and Simulink, currently a de facto visualisation and numerical processing standard. Some comparison to other programming languages, in particular Fortran and C, is provided. The main programming elements are introduced and used in examples: data input, processing, output in numerical and graphical forms, programming tools and structures (loops, conditional statements and other flow control). The course introduces selected principles of dynamic systems analysis such as transfer functions applied to environmental systems in the form of examples and case studies.

Syllabus: course consists of 30 2-hour interactive computer based workshops

Workshop	*Title*	*Lecturer*
	Introduction; Aims of programming; Course aims; Basic definitions; The scientific method; Programming languages: development, common features, application areas	WT/AC
	Starting and using Matlab; scripts; toolboxes; search paths; variables and expressions; programmer's tools: editor/debugger; Program control: loops and nested loops;	
	The concept of a dynamic system, transfer function, ADZ model of dispersion in a river	
	Introduction to graphical simulation systems: Simulink, block diagrams analysis;	
	More program control: Conditional statements. Functions and subroutines	
	Simulink: second order system examples: Gilliland climate model; feedback connections.	
	First module test (week 24)	
	Matlab and general defaults handling; error handling. Files and data input and output;	
	Computer graphics and visualisation with handle graphics	
	Advanced visualisation (multivariable data) – continued from ENV201	
	Program design, libraries; program development and debugging	
	Summary and revision workshop. End of module test (week 27)	
	Case studies and dissertation data processing clinics	

Learning Outcomes:

On completion of the course the student should be able to:

Generic Outcomes

- Communicate with programming professionals on a basic level.
- Adapt the obtained MATLAB programming skills to learning of most other programming languages (such as Fortran, C).
- Solve basic data processing problems using MATLAB or other programming languages.
- Recognise the most fundamental features of computer programming languages.
- Use a sophisticated, programmable data presentation and visualisation tool; load, process and save data in numerical and graphical form.
- Describe the way in which simple mathematical concepts can be used to build models of environmental systems.

Subject Specific Outcomes

- Design, write, run and debug simple MATLAB programs; with a potential to use MATLAB as a comprehensive programming language
- Relate the concepts of serial, parallel and feedback connections to processes in the environment.
- Formulate Simulink block diagram representations of simple environmental systems.

Assessment: **CWA: 50%** **Module Test: 50%**

Details of CWA:

Coursework will include writing brief Matlab scripts based on the scripts used during workshops as well as a brief essay on selected problems of environmental systems modelling linked with these scripts and introduced during lectures/workshops. CW is submitted by the end of week 27. Open book module tests will be taken during week 24 and week 27 (weeks 4 and 7 of the course). They involve writing code snippets related to simple numerical and graphical problems, using both the worked examples from the workshops and the student's course work.

Recommended texts and other learning resources:

Young, P.C. (editor) (1993) Concise Encyclopaedia of Environmental Systems, Pergamon Press. (Lancaster University Library: 8 copies, classmark DG1 (Y)) – several articles are highly relevant to the data analysis component

A comprehensive Matlab bibliography is available at: http://www.mathworks.co.uk

There is no primary reading list, as the extensive on-line documentation files and manuals provided with Matlab, combined with the server and Web based course materials are considered to be sufficient for this course. Additional and fully optional reading list:

Hanselman & Bruce Littlefield, Mastering MATLAB 5: A Comprehensive Tutorial and Reference , Prentice Hall, 1998, ISBN 0-13-858366-8; (Lancaster University Library Classmark: AZKF.M1, 3 copies as of Dec.2000)

Rudra Pratap, Getting Started with MATLAB 5: A Quick Introduction for Scientists and Engineers, Oxford University Press, 1999; ISBN: 0195129474 (Lancaster University Library Classmark: AZKF.M1, 4 copies as of Dec. 2000)

Kermit Sigmon, MATLAB Primer, 5e CRC Press, Inc., 1998, ISBN 0-8493-1305-8

Gerard V. Middleton, Data Analysis in the Earth Sciences Using MATLAB , Prentice Hall, 2000,ISBN 0-13-393505-1

Brian D. Hahn, Essential MATLAB for Scientists and Engineers , Arnold, 1997, ISBN 0-340-69144-1

A comprehensive Matlab bibliography is available at: http://wwweurope.mathworks.com/support/books/index.php3

MODULE NUMBER: ENV.452	MODULE TITLE: VOLCANIC PROCESS FIELD COURSE		
Number of weeks: 1	*Term taught*: Lent Vacation + Intro seminars in Lent	*Contact hours*: 60	*Learning hours*: 150
Pre-requisites: LEC.424 and usually a Geology or similar UG degree		*Co-requisites*: None	Credits: 15
***Module organiser*:** Dr Mike James	***Other lecturers*:**		

Aims and scope: This course will build upon skills acquired during previous geological field courses. During an intensive week-long field course to an active volcanic region students will improve their understanding of many of the complex processes that take place both on the surface and beneath volcanoes. This will be achieved by undertaking detailed fieldwork at key localities of a basaltic volcano (Mount Etna in 2012, but the location may change in subsequent years). Students will also gain experience in hazard analysis and mitigation.

Syllabus

Seminar	Introductory seminars during Lent Term	***Lecturer***
Fieldwork	This course allows students to improve their theoretical knowledge of volcanic processes and their field skills by studying the evolution of a basaltic volcano. It will be a problem-based learning course in which students will be presented with two levels of problems. The higher level problem (e.g. understanding the plumbing system of a complex volcano or the role of 'volcano spreading' or slope instability in the evolution of volcanoes) will occupy the entire course and will form the basis for the assessment. Lower level problems will be solved at a number of key localities where students will be expected to unravel the processes involved. During the course, students will improve their observational and deductive skills, and they will learn how to work both individually and in small groups. Group discussions and group analysis of data form an essential component of this course. In addition to improving their observational and deductive skills, students will learn a number of new field techniques such as the use of GPS and other navigational and mapping methods.	MJ
Practical /workshop	Most of the relevant hands-on skills will be taught in the field. In addition there will be evening sessions on a range of volcanological topics, as well as theoretical and data interpretation sessions based on thermal infrared imagery and other important volcanological tools.	

***Learning Outcomes*:**
On completion of this module students will be able to

Generic Outcomes

- Use a range of observational, technical, deductive and analytical skills to solve problems in volcanology,
- Work effectively in groups and as individuals in demanding conditions.

Subject Specific Outcomes

- Systematically identify volcanic rocks in the field.
- Use observations and knowledge of field relationships to reconstruct conditions during the formation of volcanic rocks.
- Gain a deep understanding of the effusive, explosive and intrusive processes that take place during volcanic eruptions.
- Recognise the role of regional tectonics, gravitational deformation of the volcano and major slope instabilities on the evolution of basaltic volcanoes.
- Explain the problems of dealing with volcanic hazards on heavily populated active volcanoes.

Assessment: CWA: 100%

Details of CWA:
Two equally-weighted parts:

1) A write up of the field course; unravelling field relationships at a number of key localities, describing the processes involved in their formation and placing them in context with primary literature.
2) A hazard assessment project (~2000 words) that covers a realistic future scenario at Mt. Etna.

The cwa is designed to test the outcomes above and this is reflected in the marking schemes.

Recommended texts and other learning resources:
Core text for Etna: John Guest, Paul Cole, Angus Duncan & David Chester 2003. Volcanoes of Southern Italy. Geological Society of London.

2012-13

MODULE NUMBER: ENV.457	MODULE TITLE: AIR QUALITY & CLIMATE		
Number of weeks: 5	*Term taught:* M1	*Contact hours:* 27	*Learning hours:* 150
Pre-requisites: willingness to tackle a little chemistry & maths in some depth		*Co-requisites:*	*Credits:* 15
Module organiser: Prof Nick Hewitt		***Other lecturers:***	

Aims and scope: This module examines air pollution by gases and particles, and describes how this air pollution can interact with climate. The principal sources, sinks, and reactions of pollutants are described along with the physical processes controlling aerosol behaviour.

Syllabus

Lecture	**Title**
1	Atmospheric structure
2-4	Simple models of climate balance
5	The carbon cycle
6-8	The atmospheric aerosol
9-10	The direct and indirect aerosol effects on climate
11	Stratospheric ozone destruction
12	Acid rain
13-15	Photochemical smog (and climate)
Practical/ workshop	**Title**
1-5	Radiative fluxes at Hazelrigg Size distributions Determination of ozone and nitrogen oxides in air Airborne particulate matter Student presentations

***Learning outcomes*:**
On completion of this module a student will be able to:

Generic outcomes:

- Produce meaningful histograms from population data, and discuss the statistical significance of different population distributions
- Carry out independent literature review and present the review — concisely and at a 400-level — to a group of peers.

Subject specific outcomes:

- Describe the Earth's energy balance and its interaction with atmospheric pollution
- Describe the major sources sink and chemical processes affecting air pollution
- Describe the physical process affecting the lifetime of atmospheric aerosol particles

Assessment: **CWA: 50%** **Exam: 50%**

Details of CWA:
One practical report and one presentation to class, including extended abstract, each carrying equal weight

Recommended texts and other learning resources:

MZ Jacobson, *Air Pollution,* Cambridge, 2002
Hewitt and Jackson, Atmospheric Science for Environmental Scientists, Wiley, 2009

****Please note: This is an unassessed module to be taken as required****

MODULE NUMBER: ENV 460	**MODULE TITLE: NUMERICAL SKILLS**		
Number of weeks: 10	*Term taught*: M1 & M2	*Contact hours*: 30	*Credits*: None - Masters support course
Pre-requisites: None	*Co-requisites*: None		
Module organiser: Dr. A. Chotai	***Other lecturers***: Dr. S. J. Lane		

Aims and scope: The module is designed to give Master students (without A-level maths or basic numerical skills) a foundation course in the numerical skills required for studying Masters Degrees within LEC. The course concentrates on explicit links between the mathematical analysis and physical processes involved with environmental systems. In this regard, environmental case studies are employed throughout the course and a number of environmental data sets are analysed. The module consists of 10 3-hours lectures/workshops.

Syllabus

Lecture	**Title**	**Lecturer**
1-2	**Units and Dimensions:** SI unit system; unit conversion; dimensional analysis; exercises based on environmental examples.	AC
3-4	**Algebra:** this most essential of numerical skills often causes great difficulty and impedes progress in other areas of numerical work. Here we concentrate on the components of equations (constants, variables, operators) and how to manipulate them into more useful forms.	AC
5-6	**Graphs, Linear Functions and Quadratic equations:** axes; plotting points; clear presentation; plotting equation of a straight line y=mx+c; slope and gradient. Exercises based on environmental examples, e.g field data from a variety of sources.	AC
7-8	**Exponential and logarithmic functions:** integer and fractional (surds) powers; negative powers; e; $\log_{10}$; ln; relationship between logs and exponents; plotting logarithmic and exponential functions; Exercises based on environmental examples	AC
9	**Power law and Exponential Law:** Transformation to linear form.	AC
10	**Basic Trigonometry:** Sine, Cosine, Tangent. Degrees and radians; Oscillatory behaviour and Periodicity; Seasonal variation; Exercises based on environmental examples,	SJL
11-12	**Differentiation :** Notation; Basic definition; Rates of change; gradient;	AC
13-14	**Area under a curve:** trapezium rule; Simpson's Rule	AC
15-16	**Integration:** Notation; Basic definition; Inverse of differentiation.	AC
17-20	**Environmental Statistics and data analysis**	SJL
Practical/ workshop	**Title**	**Lecturer**
1-10	Supervised paper exercises on material from the lectures.	AC/SJL

***Learning outcomes*:**
On completion of this module a student will be able to:

Generic Outcomes

- Manipulate basic mathematical equations.
- Describe logarithmic and exponential functions.
- Use dimensional and/or unit analysis on simple equations
- Describe the basic principles of calculus
- Solve simple differential equations

Subject Specific Outcomes

- Apply the concepts outlined in the generic outcomes to environmental examples including radioactive decay.

Assessment: **CWA*: 40%*** **Module test*:60%***

Details of CWA:
CWA worksheet with both abstract and applied problems and **Open book Module Test**

Recommended texts and other learning resources:
There are no recommended books since all books on the subject are designed for more specialist audiences. However, the following texts can be useful to the course if read with discretion:

Booth, D.J. 1998. Foundation Mathematics, Addison-Wesley
James, G. 1996. Modern Engineering Mathematics, Addison-Wesle
Chotai, A. and Lane, S.J. (2011) Extensive module Lecture Notes.
Online lessons and tasks from MyMaths (http://www.mymaths.co.uk/)

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Module number: **GEOG400**	*Module title*: **Research Methods**		
Number of weeks: 10	*Term taught*: Michaelmas	*Contact hours*: 25	Learning hours: 150
Pre-requisites: None	*Co-requisites*:		Credits: 15
Module organiser: Dr Rebecca Ellis	***Other lecturers*:** Dr. Will Medd; Dr. Saskia Vermeylen Dr Nigel Watson, Dr Andrew Jarvis		

***Aims and scope*:**
This module is designed to provide students with a critical understanding of the research process and the main approaches, methods and techniques which are typically used for research. The module is intended to enable students to undertake their own independent research as part of their Masters degree and to provide a solid foundation for PhD research.

Syllabus

PART 1: : KEY ISSUES AND STRATIEGIES IN SOCIAL SCIENCE RESEARCH

W1 - What is research? Philosophies and approaches in science.
W2 Using the literature and ethics and
W3 Designing and managing research projects
W4 Qualitative evidence
W5 Quantitative evidence

PART 2: ACTION LEARNING
W6-10 Working in groups (5-6 students) and a staff member you will choose a research topic and design, conduct and report on their research over the 5 week period, supported via weekly tutorials with the staff member.

***Learning objectives*:**

On successful completion of this module, students will:

- Be aware of the importance of situating decisions about methods through reference to the way science philosophies and existing literatures shape research design;
- Be able to explain a range of ethical issues and dilemmas associated with research and ways of managing these issues and dilemmas;
- Be aware of ways of using secondary data to develop original research;
- Have knowledge of a range of qualitative and quantitative research methods and the conside have

to be made when deciding whether to use the methods, when executing the methods and when analysing and disseminating data;

- Be capable of designing, executing, analysing and disseminating their own research projects in a way that results in aims and objectives being effectively fulfilled.

Assessment: CWA: 100%
4000 word group report outlining the research problem, ethical issues and approaches, key literature, methods, findings and conclusions (50%)
2000 word individual 'retrospective' research proposal.

Details of CWA:

This module is assessed by two pieces of coursework. An group report on a miniis required that sets out and justifies the way you would approach the issues covered in the module in the context of an exemplary research project

Key texts and other learning resources:
http://www.bbc.co.uk/programmes/b01b1ljm (compulsory listening)
Denzin, N. and Lincoln, Y. (Eds) (2005) *The Sage handbook of qualitative research (3rd edition),* London: Sage
Flowerdew, R. and Martin, D. (Eds) (2005) *Methods in Human Geography*, Longman, Harlow
Silverman, D. 2005: *Doing qualitative research (2nd edition)*. London: Sage.

Module number: **GEOG410**	*Module title*: **Perspectives on Environment and Development**		
Number of weeks: 10	*Term taught*: Michaelmas	*Contact hours*: 25	Learning hours: 150
Pre-requisites: None	*Co-requisites*:		Credits: 15
Module organiser: Dr Saskia Vermeylen	***Other lecturers*:** Dr Rebecca Ellis		

***Aims and scope*:**
This module aims to provide a theoretical foundation for the study of development and the environment from a geographical perspective. As such, it will focus on understanding the ways that scholars have brought together development theory with the analysis of nature-society relations in the majority (i.e. 'developing') world. The intent of the module is to provide students with a critical understanding of the evolution of contemporary development discourses, and new ways of thinking about the relationships between environment and development. Some of the key topics that will be discussed are: theories of development, ecosystem services, property rights and the commodification of nature, biotechnology.

Syllabus

Lectures	***Title***
1-10	To be advised

***Learning objectives*:**
The learning outcomes for this module revolve around the acquisition of necessary academic skills, and the acquisition and development of particular kinds of specialised knowledge. In relation to the former category, students completing this module will:

- Acquire advanced skills for developing a reasoned arguments by evaluating, interpreting and providing a critique of complex evidence;
- Understand the relationship between theory and practice, both in a 'development' context and in the formulation and conduct of academic research;
- Begin to develop an appropriate academic writing style and method;
- Learn to critique and comment on development-and-environment scholarship, both in the written word and in conversation.

In relation to the development of specialised knowledge relating to development and environment, students will become familiar with:

- A range of theoretical arguments about development, from modernisation theory to sustainable development to post-development;
- Geographical approaches to the study of nature and society, including cultural ecology and political ecology;
- New themes and considerations in the geography of development.

Assessment: CWA: 100%

Details of CWA: This course is assessed by a 5000 word essay.

Key texts and other learning resources:
Reading list and key texts will be supplied at the first lecture

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MODULE NUMBER: GEOG413		MODULE TITLE: GEOINFORMATICS	
Number of weeks: 10	*Term taught*: L1 & L2	*Contact hours*: 25	*Learning hours*: 150
Pre-requisites: None	*Co-requisites*:		Credits: 15
Module organiser: Dr Alan Blackburn	***Other lecturers*:** Duncan Whyatt, Gemma Davies		

***Aims and scope*:**

This module introduces students to the fundamental principles of GIS and Remote Sensing (RS) and explores how these complimentary technologies may be used to capture, manipulate, analyse, display and communicate different forms of spatially-referenced environmental data. This is a highly vocational module with lectures complimented by computer-based practical sessions using state-of-the-art software (ArcGIS and ERDAS Imagine) on related themes. At the end of the module students are required to complete a Geoinformatics project on a topic of their own choice in a geographic location of their own choice.

Syllabus

The following topics will be covered in lectures:

Geoinformatics – definitions, components and the nature of spatial data
Principles of RS: physical basis, sensors, platforms and systems
Applications of RS
Principles of GIS
Vector GIS
Geoinformatics project design
Raster GIS and spatial modelling
Data Integration and Metadata

The following topics will be covered in practicals:

Getting to know ArcMap (ArcGIS)
Exploring multispectral data and radiometric enhancement (ERDAS)
Spatial enhancement and image rectification (ERDAS)
Spectral enhancement, classification and data fusion (ERDAS)
Landsat 7, Data Preparation and Supervised Classification (ArcGIS/ERDAS)
Data Integration (ArcGIS)
Exploring Mastermap and LiDAR data (ArcGIS)
Change detection analysis (ArcGIS)
Raster analysis: Simple Map Overlay (ArcGIS)
Cartography (ArcGIS)

***Learning objectives*:**

On successful completion of this module a student will gain:

- An understanding of the fundamental principles and applications of GIS, RS and spatial modelling;
- An appreciation of the strong linkages between the above disciplines and their fusion to create meaningful spatially-referenced environmental information;
- An appreciation of applications of Geoinformatics as reported in the scientific literature;
- Training in the use of advanced software packages such as ArcGIS and ERDAS Imagine;
- Project management skills through completion of a Geoinformatics project.

Assessment: **CWA: 100%**

Details of CWA:

1 x 2500 word review of the Geoinformatics literature focussing on areas linked to specific scheme of study (50%). 1 x 2500 fully-illustrated project report (50%). Further details of both pieces of course work assessment will be given in the first lecture.

Key texts and other learning resources:

Brebbia, C.A. and Pascolo, P. (Eds.), 2000, *Management Information Systems 2000: Vol 1* . MIT Press.

Brimicombe, A., 2003, GIS, *Environmental Modelling and Engineering*. Taylor & Francis.

Camara, A.S., 2002, *Environmental Systems: A Multidimensional Approach (Spatial Information Systems)*. OUP

Clarke, K.C. et al. (Eds), 2003, *Geographic Information Systems and Environmental Modelling (4e)*. Prentice Hall.

Falkner, E. and Morgan, D.D., 2001, *Aerial Mapping: Methods and Applications*. Lewis Publishing.

Heywood, I, Cornelius, S and Carver, S, 2006. *An Introduction to Geographical Information Systems (3e)*. Pearson

Longley, P.A, Goodchild, M.F, Maguire, D.J and Rhind, D.W,. 2005, *GIS and Science*. Wiley.

Sinha, A.K., 2006, *Geoinformatics : Data to Knowledge*. Geological Society of America.

Skidmore, A., 2002, *Environmental Modelling with GIS and Remote Sensing*. Taylor & Francis.

Wilson, J.P and Fotheringham, S, 2008. *The Handbook of Geographic Information Science*. Blackwell

Module number: **GEOG414**	*Module title*: **ENVIRONMENTAL MANAGEMENT**		
Number of weeks: 10	*Term taught*: Michaelmas	*Contact hours*: 25	*Learning hours* 150
Pre-requisites: None	*Co-requisites*:		*Credits:* 15
Module organiser: Dr Nigel Watson	***Other lecturers*:**		

***Aims and scope*:**

This module is designed to provide students with a critical understanding of key concepts, principles, tools and techniques for the management of natural resources and the environment. Particular attention is given to the challenges of dealing with complexity, change, uncertainty and conflict in the environment and to the different management approaches which can be deployed in 'turbulent' conditions. The following topics will be covered in the ten 2.5 hour sessions.

Syllabus

Lecture Title	*Lecturer*
Resource Planning and Management in Turbulent Environments	NMW
Futuristic Approaches and Methods	NMW
Ecosystem-Based Management	NMW
Uncertainty and Adaptive Environmental Management	NMW
Public Participation and Partnerships	NMW
Utilizing Local Knowledge	NMW
Social Learning	NMW
Resolution of Environmental Disputes	NMW
Implementation of Resource and Environmental Policy	NMW
Evaluation of Resource and Environmental Policy	NMW

***Learning objectives*:**

On successful completion of this module, students will:

1. Have a critical appreciation of the nature of resource and environmental management;
2. Be critically aware of the underlying characteristics and challenges associated with specific contemporary environmental problems;
3. Have in-depth knowledge of a range of different approaches and strategies which may be used for the management of natural resources and the environment;
4. Be able to critique current environmental management policies and practices, and be able to develop constructive proposals for future public policy.

Assessment: **CWA: 100%**

Details of CWA:

This course is assessed solely by coursework. Each student is required to complete two pieces of assessed work, each of which should be approximately 2,500 words in length.

Key texts and other learning resources:

Lachapelle, P.R, McCool, S.F. and Patterson, M.E. (2003), 'Barriers to effective natural resource planning in a "Messy" world', *Society and Natural Resources*, 16, pp.473-490.

Watson, N.M. (2005), 'Integrated River Basin Management: A Case for Collaboration', *International Journal of River Basin Management*, 2 93), pp.1-15.

Creighton, L.L. (2004), 'Designing Effective Public Participation Programs', *Water International*, 29(3), pp.384-391.

Lawrence, R.L. and Deagan, D.A. (2001), 'Choosing public participation methods for natural resources: a context-specific guide', *Society and Natural Resources*, 14, pp. 857-872.

Pinkerton, E. (1996), 'The contribution of watershed-based multi-party co-management agreements to dispute resolution: the Skeena watershed Committee', *Environments*, 23(2), pp.51-68.

Andrew, J.S. (2001), 'Making or breaking alternative dispute resolution? Factors influencing its success in waste management conflicts', *Environmental Impact Assessment Review*, 21, pp.23-57.

Moore, S.A. and Lee, R.G. (1999), 'Understanding dispute resolution processes for American and Australian public wildlands: towards a conceptual framework for managers ', *Environmental Management*, 23(4), pp.453-465.

Chess, C. (2000), 'Evaluating Environmental Public Participation: Methodological Questions', *Journal of Environmental Planning and Management*, 43(6), pp.769-784.

Module number: **GEOG415**	*Module title*: **Environmental Justice**		
Number of weeks: 10	*Term taught*: Lent	*Contact hours*: 25	Credits: 15
Pre-requisites: None	*Co-requisites*:		
Module organiser: Professor Gordon Walker	***Other lecturers*:**		

***Aims and scope*:**

This module critically examines environmental justice as a new agenda and discourse for environmental policy and politics. It considers how the environment and the practices of environmental management have equity and justice implications for different social groups and the research, policy debates and political action that have focused on questions of both distributive and procedural justice. The module is international in scope considering experience in the US, UK and Europe and environmental and risk issues that operate across local to global scales. You will be encouraged to think critically and creatively about questions at the forefront of current political, policy and academic agenda.

Syllabus

Lecture	*Title*	*Lecturer*
1	Environmental Justice: health, well being and social difference	
2	Environmental Justice in the USA: framing, politics and policy	
3	Globalising Environmental Justice	
4	Claim Making and Concepts of Justice	
5	Who suffers, who benefits?: Distributive Justice and Environmental Inequality	
6	Case Studies (student presentations)	
7	Case Studies (student presentations)	
8	Environmental Justice in Policy and Environmental Management	
9	Fairness in Decision Making: Procedural Justice	
10	Justice, Fairness and Climate Change	

***Learning objectives*:**

By the end of this module you will have:

- An understanding of core principles and concepts of environmental justice
- An understanding of the evolution of environmental justice discourse, politics and policy making in the US, UK and other parts of the world
- An ability to critically evaluate evidence of patterns of distributional environmental inequality and their causation and claims made for environmental (in)justice at local through to global scales
- An understanding of theoretical and practical issues of procedural (in)justice in the context of public participation in environmental decision-making
- An ability to evaluate and categorise arguments about justice in climate change debates

Assessment: CWA: 100%

***Details of CWA*:**

The course will be assessed through **two** 2500 word essays.

***Key texts and other learning resources*:**

A key resource for the module are the web pages on environmental justice hosted at Lancaster University. This contains background material, a bibliography, copies of a range of reports I have been involved in producing and links to other sites:

http;//www.geography.lancs.ac.uk/envjustice

Walker G (2011) Environmental Justice: Concepts, Evidence and Politics (London, Routledge)
Agyeman J, Bullard R and Evans B (2003) Just Sustainabilities: Development in an Unequal World (Earthscan, London)
Camancho D E (ed) 1998 Environmental injustices, political struggles: race, class and the environment, (Duke University Press, Durham and London)
Low, N. and Gleeson, B. (1998) Justice, Society and Nature: an exploration of political ecology (London, Routledge)
Scholsberg D (2007) Defining Environmental Justice: theories, movements and nature (Oxford, OUP)

Module number: **GEOG416**		*Module title*: **Environmental Auditing**	
Number of weeks: 10	*Term taught*: Lent	*Contact hours*: 25	Credits: 15
Pre-requisites: None		*Co-requisites*:	
Module organiser: Dr Nigel Watson		***Other lecturers*:**	

***Aims and scope*:**

This module is designed to provide students with a basic understanding of the principles, methods and practices of environmental auditing. The function of an environmental audit will be reviewed, along with the different types and methods for gathering audit evidence. Key environmental legislation affecting organizations in the UK is reviewed, along with the use and design of Environmental Management Systems (EMS) and also ISO standards for auditing and EMS. The module includes a practical auditing exercise, a written test and additional course work.

The following topics will be covered in the ten 2.5 hour sessions:

Syllabus

Lecture	*Title*	*Lecturer*
1.	Introduction to environmental auditing	NMW
2.	Gathering evidence and assessing impacts	
3.	EU environmental policy	
4.	UK environmental law and regulation	
5.	Origins and elements of EMS; EMS auditing	
6.	Types and sources of contaminated land	
7.	Methods of remediation	
8.	Pre-audit preparation	
9.	On-0site audit exercise	
10.	Audit reporting	

***Learning objectives*:**

On successful completion of this module, students will:

1. Know about the origins, principles and methods of environmental auditing;
2. Understand how to successfully design, conduct and report on an environmental audit or review;
3. Have developed organisational and interpersonal skills appropriate for environmental auditing;
4. Be aware of key EU and UK environmental policy, legislation and regulations;
5. Understand the principles of environmental management systems;
6. Have a basic understanding land contamination and methods of remediation;
7. Have gained practical experience of undertaking and environmental audit as part of a team;
8. Be aware of the professional standards and guidelines applicable to environmental auditing in the UK.

Assessment: CW 70% (20+50); End-of-module test 30%

Key texts and other learning resources:

Training manuals are provided as part of this module. Additional materials includes the following:

Gilbert, M. and Gould, R. (1998), Achieving Environmental Standards (2nd Edition), Pitman Publishing. ISBN 0-273-63100-4.
Hoggart, C. (1999), Environmental Auditing for the Non-Specialist, Chandos, Oxford.
Humphrey N. and Hadley M. (2000), Environmental Auditing, Palladian Law Publishing, Isle of Wight.

MODULE NUMBER: GEOG419	MODULE TITLE: HEALTH AND ENVIRONMENT		
Number of weeks: 10	*Term taught: Michaelmas*	*Contact hours: 25*	*Learning hours: 150*
Pre-requisites: Admission to a relevant Masters degree course		*Co-requisites: None*	*Credits: 15*
Module organiser: *Professor Colin Pooley*		***Other lecturers:***	

Aims and scope:

The course examines geographical approaches to the study of health and environment, focusing on the investigation of spatial variations in disease incidence, the epidemiology of selected diseases, the links between environment and health and problems of access to healthcare. Students will gain a sound understanding of these issues and should acquire research skills that will enable them to undertake their own investigations. The main emphasis of the course is on Britain and Western Europe, though selected examples may be drawn from other parts of the world. The course is taught by a combination of lectures and seminar discussions and students are encouraged to relate the issues considered to their own experiences.

Syllabus

Lecture	**Title**	**Lecturer**
1.	Introduction to the course: approaches to the geography of health	CGP
2.	The historical geography of disease and public health	CGP
3.	Access to and utilisation of health care	CGP
4.	Disease Ecology	CGP
5.	Inequalities in health	CGP
6.	Health policies	CGP
7.	Alternative and complementary therapies	CGP
8.	Gender and health	CGP
9.	Health and the urban environment	CGP
10.	Globalisation and health: conclusion to the course	CGP

***Learning outcomes*:**

On completion of this module a student should be able to:

- demonstrate a critical understanding of key issues in the geography of health
- relate these to real world problems and to the students' own experiences
- apply research skills relevant to investigations in the geography of health
- demonstrate the ability to write critically about selected issues in the geography of health

Assessment: CWA: 100%

Details of CWA:

One 5000 word research assignment

Recommended texts and other learning resources:

Curtis S. *Health and inequalities: Geographical perspectives.* London: Sage, 2004.
Gatrell A. and Elliott, S. *Geographies of health: an introduction.* Chichester: Wiley-Blackwell, second edition 2009 (or read the 1st edition 2001)
Meade MS, Earickson RJ. *Medical geography.* London: Guilford Press, 2000.
Gesler, W. and Kearns, R. *Culture/place/health*, London, Routledge, 2002.
Parr, H. *Mental health and social space*, London: Blackwell, 2008.

You should also read extensively from the journals *Health and Place* and *Social Science and Medicine*. A full reading list will be provided at the outset of the module.

Module number: **GEOG421**	*Module title*: **Sustainable Water Management: Concepts, Governance and Practice**		
Number of weeks: 10	*Term taught*: Michaelmas	*Contact hours*: 25	Learning hours: 150
Pre-requisites: None	*Co-requisites*:		Credits: 15
***Module organiser:* Will Medd**	***Other lecturers*:**		

***Aims and scope*:**
The module aims to develop understanding about key concepts, debates and policies in the governance and practice of sustainable water management in the UK. This will include developing an ability to apply such understanding to the analysis of examples of sustainable water management and assess the strengths and weakness of particular policy approaches. Please note each week the sessions are organised around activities that are based on core readings students are expected to do.

Syllabus

Lecture	*Title*	*Lecturer*
1	Part 1 Concepts of sustainable water management	WM
2	What sort of resource is water?	
3	How is the concept of sustainability applied in water management?	
4	What does water governance mean?	
	The Water Framework Directive	
5	Part 2 – Governance and practice	
6	Catchment Management and Water Quality	
7	Flood Risk Management	
8	Water resource management	
	Drought and demand side management	
9 and 10	Part 3 – Case studies	
	Student presentations	

***Learning objectives*:**
On successful completion of this module, students will:

* know about key concepts, debates and policies through study of the literature on the governance and practice of sustainable water management

* be able to analyse case studies in sustainable water management and assess the strengths and weakness of particular policy approaches

* have developed an ability to engage in policy analysis and evaluation for sustainable water management.

* have developed and practised the skills of working in groups, critically evaluating research on sustainable water management, undertaking presentations and academic writing

Assessment: CWA: 100%

Details of CWA:
This course is assessed by two pieces of coursework: one essay (70%) and a piece of group work (30%)

Key texts and other learning resources:
Each week four readings are set – these may be a combination of articles, book chapters or policy documents. There is no single core text. Here are some examples:

Bakker K. (2003) *An uncooperative commodity: Privatizing Water in England and Wales*, OUP: Oxford, Chapter 3 and 4.

Defra (2008) *Future Water: the governments water strategy for England*, HMSO: London

Johnson C., et al (2005) "Floods as Catalysts for Policy Change: historical lessons from England and Wales", *International Journal of Water Resources Development*, 21 (4): 561-575

Macleod, C. J. A., D. Scholefield, Haygarth, P. M. (2007). "Integration for sustainable catchment management." *Science of the Total Environment* 373(2-3): 591-602.

Medd, W. and Chappells, H. (2007) 'Drought, demand and scale: fluidity and flexibility in the framing of water relations', *Interdisciplinary Science Reviews*, 32 (3): 233-247

Strang, V. (2003) *The Meaning of Water* Berg: Oxford, Chapter 9, 'Governing Water'

MODULE NUMBER: GEOG 422		**MODULE TITLE: DISASTER MANAGEMENT**	
Number of weeks: 10	*Term taught: Lent*	*Contact hours: 20*	*Learning hours: 150*
Pre-requisites: none		*Co-requisites: none*	*Credits: 15*
Module organiser: Professor Ian Marshall		***Other lecturers: none***	

Aims and scope: The module introduces students to important aspects of disaster management in a wide variety of geographical contexts. The module provides a critical appreciation of: (i) the processes involved in natural disaster events (including those that occur after any environmental initiator) and (ii) the assessment of economic, social and environmental impacts and then applies this appreciation to the top level design and implementation of effective hazard management measures.
The module will examine the impacts of hazard events with respect to the Third World and the developed countries particularly the UK and Western Europe, and will do so at a variety of scales from the local to the multi-national. Students will be introduced to different approaches to the analysis of hazard. The role of planning will be critically examined both as a means of mitigating hazard directly and as a tool for highlighting areas where more dynamic mitigation measures such as raising community awareness, improving transport and communications infrastructure, or installing warning systems. Alternative styles of management will be assessed for their potential applicability in a range of specific case study areas.

Syllabus

Session	**Title**	**Lecturer**
1	Overview of Hazard and risk (lecture + discussion)	Professor
2	Introduction to full range of natural disasters, associated socio-technical hazards and their management (presentations/discussion)	Marshall
3	Develop understanding of large uncertainties in hazard information sources (seminar with discussion)	
4	Application of hazard estimation to specific sites (presentations and discussion)	
5	Costs, benefits and failures of management measures (lecture + discussion)	
6	Detailed investigation of existing management at specific sites (presentations and discussion)	
7	Designing management measures (Group exercise)	
8	Proposing additional management measures (presentations/discussion)	
9	Global hazard management and climate change (lecture/discussion)	
10	Convincing planners and managers (lecture and discussion)	

***Learning outcomes*:**
On completion of this module a student should be able to:

- describe the principal causes of environmental hazard, in the UK, Europe and elsewhere;
- understand how hazard affects areas economically, socially, culturally and environmentally; understand the social, spatial and temporal interactions inherent in hazard;
- appreciate the difficulties and effects of planning for hazard at different scales; appreciate the limitations of purely engineered approaches to disaster management;
- apply their knowledge (from various disciplinary backgrounds) to the construction of clear and cogent arguments (in text and orally through the presentations, debates in class and written coursework); that use case-study and statistical materials effectively, and can form the basis of convincing proposals

Assessment: CWA: 100%

Details of CWA:
The module is assessed entirely by coursework. Students are required to write 4 presentations;

- Introduce a hazard type, typical management measures associated with it and their effectiveness (wk 2)
- Assess in detail the hazards associated with 3 named hazard areas (wk 4)
- Discuss existing management measures for a specific hazard area in detail (wk 6)
- Propose and motivate new management measures for 3 named hazard areas facing similar hazards (wk 8)

and write a 2500 word **Proposal** (including high level cost/benefit analysis) for additional management measures that could be adopted in a current hazard situation.

Recommended texts and other learning resources:
The module makes intensive use of a set book -Smith, K. (2009) *Environmental hazards – assessing risk and reducing disaster*. Routledge.
Students are expected to obtain a copy, and read it during the first 2 weeks.
Additional references will be drawn from the web as required

MODULE NUMBER: GEOG423		MODULE TITLE: ENVIRONMENTAL INFORMATICS IN PRACTICE	
Number of weeks: 10	*Term taught: Lent*	*Contact hours: 35*	*Learning hours: 150*
Pre-requisites: previous experience with databases		*Co-requisites:GEOG 413 or prior experience with GIS tools*	***Credits: 15***
Module organiser: Phil Trembath		***Other lecturers:*** CEH Staff in LEC	

Aims and scope: This module is being run in conjunction with the Centre for Ecology and Hydrology (CEH). CEH staff have specialist skills in a wide range of terrestrial and freshwater environmental disciplines, ranging from the smallest scale (the gene) to the largest (whole Earth systems). Many of the CEH staff you will meet during the course work on large-scale, long-term environmental research generating large volumes of data. Students will go through the practical processes of capture, storage, validation, transformation, integration, analysis and presentation of environmental data used in CEH. Students will undertake a mini-project where they propose and implement modifications to the existing information workflow that allow them and other users to address one or more typical science questions, such as "where has soil pH changed along with changes in vegetation condition that are associated with changes in larger scale habitat".

Syllabus

CEH practices and database mini-project

1	Introduce the aims and objectives of the module, outline expectations of students' learning style and introduce development methods. Students will also learn more about the datasets they will be working with.	Phil Trembath
2	Conduct an initial client meeting	Phil Trembath
3	From the information provided in weeks 1 & 2, students will produce a plan for the development of the project in coming weeks.	Phil Trembath
4	Working as a group and guided by CEH teaching staff, the students will construct and populate a data schema. The schema design will be submitted in part fulfilment of the module assessment. During the session the students will implement the schema.	Phil Trembath
5	As a group, the students will conduct tests of their solution. By the end of the session, a solution should be produced that is suitable for user testing in week 5.The students will work with the user to test the solution, get feedback and begin to conceive a plan for the second iteration of development.	Phil Trembath
6-9	The students will lead and complete a second iteration of the development taking account of feedback from the client and lessons learned from the previous iteration. Each week CEH teaching staff will be available to answer any questions that may arise or to offer any other necessary support and guidance.	Phil Trembath
10	The students will have completed the second iteration of their development and each student will independently complete a test of the solution. They will each write a test report to be handed in at the end of week 10. A further evaluation of the whole development process will be completed by each student to be handed in at the start of the following term.	Phil Trembath

***Learning outcomes*:**
On completion of this module a student should be able to: Analyse and propose improvements to a database, Implement improvements to a database, Organise a team to implement more extensive improvements to a data base, Document improvements to a database in a form that can be used by other environmental professionals, use the database to answer an outstanding science question.

Assessment: CWA: 100%

Details of CWA:
Write a short project plan (10%), write a requirements document (10%, groupwork), implement database (20%, groupwork), write a 2000 word report on testing the database (30%), write a 2000 word evaluation report (30%).

Recommended texts and other learning resources:

Teach yourself SQL in 21 days Plew & Stephens 2002 (SAMS).
You will find it helpful to learn more about CEH and some of the large-scale, long-term environmental research it does before the course starts. CEH - www.ceh.ac.uk Countryside Survey - www.countrysidesurvey.org.uk Environmental Change Network - www.ecn.ac.uk
Any Problems? Please contact John Watkins (jww@ceh.ac.uk) in the first instance.

MODULE NUMBER: LEC.422		MODULE TITLE: DATA ASSIMILATION AND INTEGRATION	
Number of weeks: 5	*Term taught*: M2	*Contact hours*: 30	*Notional hours*: 150
Pre-requisites: Elementary maths, equivalent to ENV460, familiarity with Microsoft Excel		*Co-requisites*:	*Credits*: 15
***Module organiser*:** Dr Mike James		***Other lecturers*:** Prof. Ian Marshall	

***Aims and scope*:** Current approaches to cutting edge research in the environmental sciences are highly dependent on digital data, and a wide variety of data types and a large quantity of information can now be delivered relatively easily. This module aims to teach the fundamentals of accessing, annotating, analysing and interpreting digital data from a variety of sources, in an integrated methodology. The data manipulation skills and awareness of available tools to maximise the utility of heterogeneous digital data will be developed. Everyday problems in data collection, both avoidable and unavoidable will be demonstrated, together with annotation techniques that minimise their impact. The strengths and weaknesses of current tools for data mining and visualisation will be presented and discussed. Data from a wide range of sources will be critically assessed for quality, accuracy and utility for environmental applications. Datasets from across the environmental sciences will be used throughout the course and the techniques and benefits of integrating different data streams illustrated.

Syllabus

Week	*Title*	*Lecturer*
1.	Remote sensing and georeferencing *data availability, source system properties, measurement tradeoffs, analysis tools including those for orthorectification, processing multi/hyperspectral products, data mining and visualisation, data users, commercial applications and restrictions*	M.J.
2.	Time series *tools and techniques for collection, analysis, visualisation and interpretation of time series data with a particular focus on issues requiring annotation, including non-stationarity, long range dependency, missing data, appropriate measurements and instrumentation, automation, large data volumes and real-time systems*	M.J.
3.	Ground-based techniques *oblique image and laser scan data, hand-held devices, cost versus accuracy, sensors and sensor networks, analysis and manipulation tools*	M.J.
4.	Multi-scale consilience *combining evidence from disparate sources and observation types to deliver best possible understanding of spatial and temporal issues at all scale, software and hardware requirements and future research*	I.M.
5.	Historical and other data sources *integration of historical and process-based approaches, accuracy and annotation issues, citizen-science and multi-scale integration, tools for handling long term datasets, historical data and non-conventional sources*	M.J.

Learning outcomes:
On completion of this module students will be able to:

Generic
- Work effectively within a small team
- Identify weaknesses in observations and data collection
- Analyse data and communicate results
- Use a range of standard information resources to research a problem
- Use a wide range of informatic techniques

Subject Specific
- Identify and overcome difficulties in the analysis of real and incomplete datasets
- Define metadata requirements for specific data types
- Assess the applicability of non-standard data sources
- Appropriately combine results from disparate datasets
- Understand the strengths and weaknesses of a range of observational techniques
- Make appropriate use of state of the art data mining and visualisation tools

Assessment: **CWA: 100%**

***Details of CWA*:**
Three short written seminar/practical reports (20% each)
A written, critical analysis, covering one topic area or case study (40%)

***Recommended texts and other learning resources*:**
There are no recommended books which span the full course. However, the following can be useful if used with discretion:
Lyons, L. (1991) A practical guide to data analysis for physical science students, Cambridge University Press
Campbell, J.B. (2002) Introduction to remote sensing. 3rd ed. Taylor & Francis
Longley, P.A. et al. (2005) Geographical information systems and science. 2nd ed., John Wiley and Sons.
Larose, D.T. (2005) Discovering knowledge in data: An introduction to data mining. John Wiley and Sons.

MODULE NUMBER: LEC 424	MODULE TITLE: PHYSICAL VOLCANOLOGY		
Number of weeks: 10	*Term taught: M*	*Contact hours: 33*	*Learning hours: 150*
Pre-requisites: ENV 460 if no A-level maths		*Co-requisites: None*	*Credits: 15*
Module organiser: Jennie Gilbert		***Other lecturers: HT, LW***	

Aims and scope: This module aims to provide knowledge of volcanoes and volcanic systems. Its foundations are an understanding of the properties and behaviour of volcanic materials gained through laboratory, theoretical and field study. The module emphasizes the widely-applicable physical and chemical processes that occur during volcanic activity, including variations in solubility, rheology, phase, density and permeability. The interaction of volcanic processes with the biosphere, atmosphere and hydrosphere are discussed. The products of volcanism, together with the hazard and benefits to life on Earth are studied.

Syllabus

Week	Title	Lecturer
1	Physical properties of magma 1.	HT
2	Physical properties of magma 2.	HT
3	Ancient volcanism field day. Explore a lava dome erupted c. 400 Ma ago that now forms Haystacks at the head of Buttermere in the English Lake District and the associated volcanic facies.	HT/JSG
4	Laboratory practical; introduction to use of the hotstage.	HT
5	Laboratory practical; rock hand specimen textures.	HT
6	Plumes and ash.	JSG
7	Lavas and domes.	HT
8	Laboratory practical; the 2008-09 rhyolitic eruption of Chaitén, Chile	HT
9	Non-Earth planetary volcanism 1.	LW
10	Non-Earth planetary volcanism 2.	LW

Subject specific learning outcomes
On completion of this module students will be able to:

Understand a range of broadly-applicable physical and chemical principles.
Recognise different types of volcanic activity.
Understand why volcanoes behave in different ways.
Recognise volcanism as present on many solar-system bodies.

Generic learning outcomes
On completion of this module students will be able to:

Work both independently and as part of a team on exercises out-of-doors and in the laboratory
Use numerical and written skills.
Access and use the primary literature.

Assessment: CWA: 100%

Details of CWA:
Review paper from a range of topics including your own (70%).
Laboratory practical report (30%).

Recommended texts and other learning resources:
Parfitt EA, Wilson L (2008) Fundamentals of Physical Volcanology, Blackwell Publishing, ISBN 978-0-632-05443-5.
Primary publications recommended during the module.

MODULE NUMBER: LEC.425	Module title: **Environmental Sampling and Analysis for Trace Organics**		
Number of weeks: 5	*Term taught: Lent 1*	*Contact hours: 25*	*Learning hours: 150*
Pre-requisites: A-levels math and chemistry		*Co-requisites:*	*Credits: 15*
Module organiser: Dr Andy Sweetman		***Other lecturers:***	

Aims and scope: This module is designed to provide knowledge about analytical techniques used to obtain environmental chemical data and to prepare students for their MSc thesis research or for a professional career in research, management or policy where analytical techniques are used or data from these techniques need to be interpreted. Particular attention is paid to the entire sampling-analytical system and the fundamentals of common analytical techniques in environmental analysis like mass spectrometry and chromatographic techniques. Further considerations include the quality of the analytical results, statistical interpretation etc. Lectures on organic analytical chemistry theory are complemented with practical laboratory exercises in small groups working in our LEC research laboratories. The students will be given hands-on opportunities familiarize with both classical and instrumental methods usually employed in analytical chemistry.

Syllabus

Lecture	**Title**	**Lecturer**
1-3	**Basics of Environmental Sampling and Analysis:** • Concentration units, accuracy, precisions, calibration curve, etc. • Essential of Environmental statistics • Knowledge of Environmental regulations	Andy Sweetman
4-6	**Environmental Sampling Techniques** • Environmental Sampling design • Sampling matrices and analytes • Technique for sampling various Media: practical approaches and tips.	Andy Sweetman
7-9	**Methodology and quality assurance/quality control of environmental analysis**. • Selection of analytical methods based on target compounds • Field quality assurance/quality control • Analytical quality assurance/quality control	Andy Sweetman
10-12	**Fundamentals of sampling preparation for environmental analysis (Lecture+practicals)** • Overview of sampling preparation • Extraction for SVOC and non-VOC from liquid of solid matrices (or samples) • Post-extraction and clean-up of organic compounds • Sampling preparation for VOC.	Andy Sweetman
13-15	**Chromatographic methods for environmental Analysis (lectures+practicals)** • Introduction to chromatography • Instruments for chromatographic methods (GC, LC, HPLC) • Common detectors for chromatography • Applications of chromatographic methods in Environmental analysis • Quantification and calibration curve	Andy Sweetman

***Learning outcomes*:**
At the end of this module the students should:

1. have a good knowledge of the inorganic and organic chemistry related to the chemicals in the environment and their fate
2. have an understanding of the theory of sampling preparation for environmental analysis and the principles and the operation of some of the major environmental analytical techniques
3. be aware of current issues in environmental analytical chemistry

Assessment: CWA: 50% Exam: 50%

Details of CWA:
Write a detailed laboratory report (1500 words) following the laboratory practical (35%). Write an essay describing analytical procedures and technique used to analyze a given group of target chemicals (15%)

Recommended texts and other learning resources:
Fundamentals of Environmental Sampling and Analysis. Chunlong (Carl) Zhang. A John Wiley &Sons, Inc., Publication. ISBN: 978-0-471097-4.
Piers, K. "An Introduction to Ion Chromatography". Class hand out, Calvin College, 2001.
Any Problems? If you encounter any problems during the course please contact Andy Sweetman (a.sweetman@lancaster.ac.uk).

Module number: **LEC426**	*Module title*: **Environmental Applications of Isotope Geochemistry**			
Number of weeks: 5	*Term taught:* L1	*Contact hours*: 30	*Learning hours:* 150	*Credits:* 15
Pre-requisites: ENV460 or A-level Maths		*Co-requisites*: None		
Module organiser: Greg Holland		*Other lecturers*: Jackie Pates		

Aims and scope: This module will focus on how different isotopic systems can be used to understand physical processes in the environment. The course will also consider the use of isotopes for understanding palaeoclimatic conditions and for acquiring surface and groundwater ages. The material delivered here will supported by detailed case studies. Lectures and seminars will give an up-to-date account of this fast changing subject, and will conclude with a lecture on the new scientific subject of clumped isotopes.

Lecture	*Title*	*Lecturer*
1-3	Introduction, mass spectrometry techniques, and surface dating	GH
4-6	Radioactive isotopes: rates and dates in aquatic systems	JP
7-9	Stable isotopes in the environment and palaeoenvironment	GH
10-12	Noble gas isotopes in the environment and subsurface	GH
13-15	Groundwater dating and origins, clumped isotopes, summary	GH
Practical		
1	Calculating surface exposure ages	GH
2	Calculating sediment accumulation rates	JP
3	Modelling stable isotopes in the environment: fractionation factors	GH
4	Calculating palaeotemperatures using noble gases	GH
5	Student seminars and reduction of isotope data	GH

***Learning objectives*:**
On completion of this module a student will be able to:

Generic	*Subject specific*
At a generic level, the students will be able to critically appraise aspects of the scientific literature, formulating robust scientific arguments, using recent research data from the module convenor and others to design solutions to environmental problems. They will gain an appreciation of how isotope data are acquired. Further the students will gain experience in teamwork as well as planning, researching and implementing a group presentation.	On successful completion of this module students will be able to demonstrate subject specific knowledge and: perform data analysis specific to isotopes construct simple models to describe natural systems appreciate the variety of applications of different isotope techniques and use different techniques appropriately use isotope decay equations to calculate ages

Assessment: **Exam 50% CWA 50%**

Details of CWA:
Data based project – 50%
Presentation – 50%

Recommended texts and other learning resources:

Reviews in Mineralogy and Geochemistry 43 Stable Isotope Geochemistry

Reviews in Mineralogy and Geochemistry 47 Noble Gases in Geochemistry and Cosmochemistry

Reviews in Mineralogy and Geochemistry 52 Uranium Series Geochemistry

Isotope Tracers in Catchment Hydrology. Kendall C and McDonnell, J. 1998

Isotopes : principles and applications. Faure, G., 3rd edition, 2004

MODULE NUMBER: LEC.427	MODULE TITLE: CROP PROTECTION		
Number of weeks: 5	*Term taught: M2*	*Contact hours: 30*	*Learning hours: 150*
Pre-requisites:		*Co-requisites:*	*Credits: 15*
Module organiser: Michael R. Roberts		***Other lecturers: N.D. Paul, A. Wilby***	

Aims and scope: The aim of this module is to introduce students to key issues surrounding the loss of agricultural & horticultural produce to a range of pests and diseases, and the approaches that can be used to minimise these losses. This understanding will be underpinned by providing detailed knowledge of natural plant defence mechanisms and of the biology and ecology of plant-pathogen and plant-insect interactions, and how these can be exploited to assist in crop protection.

Syllabus

Lecture	**Title**	**Lecturer**
1-3	Overview of problems in crop protection. Disease, invertebrate pests, weeds. Chemical control of pests & disease.	NDP
4	Crop protection through management practices. Agronomic practices, integrated pest management.	MRR
5	Semiochemicals	MRR
6-7	Biological control, Conservation biological control.	AW
8-9	Plant Defence.	MRR
10	Resistance genes and plant breeding for pest & disease resistance.	MRR
11-12	Genetic modification.	MRR
13-14	Alternative crop protection strategies. Plant activators, elicitors, activation of plant resistance by rhizobacteria.	MRR
Practical/workshop	**Title**	**Lecturer**
1	Biological control	MRR/AW
4	Plant disease resistance	MRR

***Learning outcomes*:**
On completion of this module a student should be able to:
- Appreciate the potential crop losses inflicted by pests and disease.
- Discuss the different strategies used by pests and pathogens to attack plants.
- Explain the genetic basis for plant resistance to pests and disease.
- Explain how co-evolution has resulted in complex interactions between herbivores and pathogens and their hosts.
- Describe a range of approaches to control pests and disease.
- Differentiate between crop protection strategies which directly target the pest and those which enhance natural biological mechanisms for pest control.
- Discuss the pros and cons of conventional pesticide use.
- Describe methods for biological control of invertebrate pests.
- Discuss the potential for GM technology in crop protection.
- Describe alternative crop protection strategies focussed on activation of plant defences.

Assessment: CWA: 50% Exam: 50%

Details of CWA:
Critical evaluation of scientific literature.

Recommended texts and other learning resources:
Plants, Genes, and Crop Biotechnology. Chrispeels & Sadava (2003), Jones and Bartlett.
Plant Pathology and Plant Pathogens. Lucas (1998), Blackwell Science.
Plant Pathology. Agrios (2005), Elsevier.
Insect-Plant Biology. Schoonhoven, van Loon & Dicke (2005), Oxford.

MODULE NUMBER: LEC428	MODULE TITLE: SUSTAINABLE SOILS MANAGEMENT		
Number of weeks: 5	*Term taught: M1*	*Contact hours:*	*Learning hours: 150*
Pre-requisites:		*Co-requisites:*	*Credits: 15*
Module organiser: Ian C Dodd (ICD)		***Other lecturers:*** ***Nick Chappell (NC), Phil Haygarth (PH), Nick Ostle (NO) John Quinton (JQ),***	

Aims and scope: The aim of this module is to introduce students to key issues surrounding the ability of the soil to produce crops, and the agricultural / economic consequences of failing to manage this resource properly. Most agricultural production is dependent on the soil not only to anchor plants, but to supply their hydraulic and nutritional needs. Furthermore, the rhizosphere (soil adjacent to the root surface) is a biological hotspot comprising micro-organisms that can directly or indirectly assist crop nutrient acquisition (rhizobia, mycorrhizae and plant growth promoting rhizobacteria) or cause disease. Increasingly, the soil is being recognised as a global resource to aid carbon sequestration (even in agricultural systems) and/or act as repository for waste derived from other industries.

Syllabus

Lecture	**Title**	**Lecturer**
1	Soil management through the ages – Sustainability vs Disaster	ICD
2	Irrigation management : Micrometerology (FAO) Approach	ICD
3	Irrigation management : Soil moisture sensors	NC
4	Irrigation management : Plant Stress Sensing	ICD
5	Soil salinity (dryland / irrigation / waste water use)	ICD
6	Tillage & erosion control	JQ
7, 8	Managing soil organic matter	ICD
9	Soil carbon sequestration	NO
10	Chemical Management of Crop nutrition	ICD
11	Biological nutrient inputs (rhizobia / mycorrhizae)	ICD
12	Soils and diffuse pollution	PH
13	Soil remediation / "Waste to land" activities	ICD
14	Soil Biology : Managing soilborne disease	ICD
15	Soil Biology : Stimulating plant growth	ICD
Practical/workshop	**Title**	
1	Visual Soils Assessment	ICD
2	Student presentations on a range of topics	ICD
3	Irrigation Scheduling using soil moisture sensors	ICD
4	Visit to Broadbalk long-term experiment at Rothamsted Research	ICD

***Learning outcomes*:**
On completion of this module a student should be able to:

- Apply soil hydraulic measurements to manage irrigation
- Understand the links between irrigation management and rootzone salinity
- Understand soil and plant-based crop nutrient management
- Evaluate the impacts of plant-microbe interactions on crop disease and nutrient status
- Appraise the impact of soil erosion on water body pollution
- Compare and contrast soil carbon stocks in agricultural / non-agricultural land and evaluate methods to raise soil carbon status

Assessment: CWA: 50 % Exam: 50 %

Details of CWA:
Practical Report based on irrigation scheduling practical (20%)
Essay on Sustainability of Management Practices (20%)
Short Oral Presentation from a choice of topics (10%)

Recommended texts and other learning resources:
Mostly primary literature available online – Also see following texts:
Frossard (2006) Function of soils for human societies and the environment
Fullen (2004) Soil management: problems and solutions
Horn (2006) Soil management for sustainability

MODULE NUMBER: LEC.429	**MODULE TITLE: CLIMATE CHANGE AND SOCIETY**		
Number of weeks: 10	*Term taught: Lent*	*Contact hours: 25*	*Learning hours: 150*
Pre-requisites: None		*Co-requisites: None*	*Credits: 15*
***Module organiser**: Kathryn Yusoff*		***Other lecturers:***	

Aims and scope:

This module aims to explore and reconfigure the ways in which climate change is understood through a focus on the social, rather than the scientific-environmental discourses that have dominated the policy and politics of climate change. This module offers students a wide-ranging and intensive introduction to the politics, cultures and theories of climate change research in the social sciences and humanities. Students will be able to critically evaluate different theoretical perspectives on a range of climate change debates and present alternative arguments.

Syllabus

Lecture	**Title**	**Lecturer**
	1. Climate Change and Society – Welcome to the Anthropocene 2. "Human Dimensions" in climate policy and science 3. Rethinking Climate Change and Society 4. Climate change and uncertainty 5. Climate Change and Risk 6. Climate Change and Biopolitics 7. Climate Change, Vulnerability and Ethics 8. Anthropocene Governmentality 9. The geopolitics of climate change or postpolitical politics? 10. Living with environmental change or cultures of change?	Dr Kathryn Yusoff

***Learning outcomes*:**
On completion of this module a student should be able to:
1 Evidence a sufficient grounding in the theoretical, political and epistemological discourses of climate change;
2 Critically analyse in writing and orally of different theoretical approaches to studying nature, society, and environmental change;
3 Discuss the social theory of climate change, in particular, evidence how climate discourse is constructed, practiced, made, and deployed within a political and cultural context;
4 Analyse the politics of climate change and discuss forms of cultural production on range of scales;
5 Discuss the range of scientific, public, governmental, non-governmental and indigenous "cultures" within the climate change debate.
6 Analyse a variety of practice-led, creative, alternative and indigenous societal responses to climate change.
7 Evidence a familiarity with the theories and philosophies of risk theory, social theory and the literatures of climate change, environment and society, posthumanism, social practice.
8 Evidence the ability to identify, analyse and evaluate a range of different societal interactions with climate.

Assessment: CWA: 100%

Details of CWA:
One essay question chosen from a selection of five. (5000 words)

Recommended texts and other learning resources:
Adger,W.N., Lorenzoni,I. and O'Brien,K. (eds.) (2009) *Adapting to climate change: thresholds, values, governance* Cambridge University Press, Cambridge, UK.

Bulkeley,H. and Newell,P. (2010) *Governing Climate Change* Routledge, Abingdon, UK.

Hulme,M. (2009) *Why we disagree about climate change: understanding controversy, inaction and opportunity*. Cambridge University Press, Cambridge.

Urry, J. (2011) *Climate Change & Society* Polity, London.

MODULE NUMBER: LEC 431	**MODULE TITLE: SUSTAINABLE SYSTEMS**		
Number of weeks: 10	*Term taught: M*	*Contact hours: 25*	*Learning hours: 150*
Pre-requisites: None		*Co-requisites:None*	*Credits: 15*
Module organiser: Ian Marshall		***Other lecturers: None***	

Aims and scope: The module aims to introduce and illustrate the interdependency between the changes needed in all aspects of human activity, at national, organisational and personal scales, for a more sustainable society. The module will discuss a range of current approaches to communicating and managing how to achieve genuine reductions in resource use, and show how they can be applied in all sectors of the economy. A wide range of topics are considered together including; The transformation of production process, infrastructures and systems; Concepts of resource efficiency, dematerialization, decoupling, clean or sustainable technologies, design for the environment, design for sustainability, industrial ecology, life cycle analysis, the reinforcing feedback links between our infrastructures and our materialist values, the need to address both resource efficiency and values. The core objective is to prepare students for employment as sustainability advisors as this is a current critical skills shortage for UK business and a major growth area in employment opportunities.

Syllabus

Lecture	**Title**	**Lecturer**
1	National planning - ZCB (UK) Factor 5 (developed countries) and computer based DECC planning tool, avoiding rebound effects	Ian Marshall
2	Systems thinking – an introduction to interdependency and its management	
3	Finance and Economics – low growth, zero growth or degrowth, are any of these possible	
4	Infrastructure design and management (water, telecom, grid, govt, schools, police, military, etc) – and how can individual/social choices influence efficiency of provision.	
5	Industry and commerce - Cradle to Cradle processing – recycling should be upcycling not downcycling, reduce waste rather than burning it etc Architecture, efficient building and heating options, social barriers, etc.	
6	Agriculture - Food system changes, sustainable diets and motivating food choices	
7	Transport - electrification opportunities and barriers	
8	Behavioural change - Objective measures and social and psychological drivers of consumption	
9	Bottom up alternatives - an introduction to transition/permaculture, and other alternative visions of future society	
10		
Practical/workshop	2 field trips are planned. One to a range of local sites, including Halton co-housing, Dewlay, Middlewood, Salt Ayre leisure centre, Growing with nature, and one to Shotton Paper mill	**Lecturer Ian Marshall**

***Learning outcomes*:**
Students will be aware of mainstream and alternative approaches to a more sustainable future in all sectors of the economy including energy, transport, buildings, finance, agriculture manufacturing and retail. They will understand and be able to use system thinking, be able to develop practical sustainability action plans, and communicate their plans in the form of sustainability proposals.

Assessment: CWA: 100%

Details of CWA:
a) National sustainability plan (current footprint and future action - proposal) (600 words - 20%)
b) sustainable business plan. Optional focus on water, heat, food, transport or any other relevant area where demand needs to be more sustainable (2000 words - 60%)
c) spreading the message – propose a campaign AND discuss the likely impacts of the campaign. (600 words - 20%)

Recommended texts and other learning resources:
Core - Factor five (Weizsacker et al, Earthscan 2009))

MODULE NUMBER: LEC432	MODULE TITLE: LOW CARBON ENERGY USE		
Number of weeks: 5	*Term taught:* Lent	*Contact hours: 30*	*Learning hours:* 150
Pre-requisites:		*Co-requisites:*	*Credits:* 15
Module organiser: : Ian Marshall		***Other lecturers: Roger Kemp***	

Aims and scope:

The energy crisis will only be solved by the exploitation of low-carbon energy supplies and a reduction in our use of energy. Energy saving offers more short-term opportunities than the creation of new supplies.
This module, designed for students with a limited background in engineering, gives an outline of how energy is used in the UK and what can be done to make savings.
The module is suitable for students considering a career in environmental science or energy management.

Syllabus

Revision of basic concepts – kinetic, potential, electrical and chemical energy; heat transfer: conduction, convection and radiation, principles of dc and ac electric circuits.
First and Second Law of Thermodynamics, Carnot cycle efficiency, practical systems for energy conversion.
Introduction to electrical technology: generation, transmission, renewable generation, management of intermittency.
UK energy statistics; where energy comes from and how it is used.
Domestic energy use, calculation of heat loss from buildings, introduction to low energy housing; heat pumps, solar energy and other relevant technologies.
Transport energy, including electric vehicles, hydrogen, biofuels and other novel systems.
Managing industrial and commercial energy use.

***Learning outcomes*:**

On successful completion of this module students will be able to analyse the energy use in a domestic building, industrial, commercial or third sector concern and make relevant proposals for its reduction. They will be able to use “carbon footprint” software to compare alternative scenarios.

Students will be able to take an overview of energy use in business. They will be able to understand the language and jargon of specialist consultants who might be brought in to advise of specific issue and they will be able to act as an "an informed customer" for such advice.

Assessment: CWA: 100%

Details of CWA: Individual essay (100%)

Recommended texts and other learning resources:

MacKay J.C., Sustainable energy without the hot air, UIT Cambridge ISBN 978-09544529-3-3
The Stern Review of the Economics of Climate Change, Cambridge. ISBN 978-0521-700801
International Panel on Climate Change (IPCC) 4th Assessment Report (May 2007)
UK Energy Research Centre. An Assessment of the Evidence on the costs and impacts of intermittent generation on the British electricity network. (available online or hard copy).
DA Bradley, Basic Electrical Power & Machines, Chapman & Hall, 1994.
FW Schmidt, RE Henderson and CH Wolgemuth, Introduction to thermal sciences, J. Wiley, New York, 1993 (2/e).

Other resources will be made available on VLE

MODULE NUMBER: LEC.435	MODULE TITLE: LAKE ECOLOGY		
Number of weeks: 5	*Term taught: M1*	*Contact hours:*	*Learning hours: 150*
Pre-requisites: Basic knowledge of Ecology		*Co-requisites:*	*Credits: 15*
Module organiser: Dr P Barker/Dr S Maberly CEH		***Other lecturers:*** Specialists in lake ecology CEH Lancaster	

Aims and scope: This module aims to introduce the principles of lake ecology, an area with an acknowledged national lack of expertise. The course presents a holistic approach to the drivers and internal interactions that control water quality in lakes. The course will teach basic ecological principles, elucidated using lake ecology, introduce application of state-of-the-art techniques and provide essential background information for anyone dealing with EU Directives such as the Water Framework Directive in the future.

Syllabus

Lecture	**Title**	**Lecturer**
Week 1	Overview to the structure and rationale of the course	
	Introduction to lakes and their role in the landscape and global cycling	P Barker
	Records of long-term change	S Maberly
	Phytoplankton & macrophytes	S Maberly
	Zooplankton	S Maberly
Week 2	Lake physics & atmospheric drivers	S Thackeray
	Lake Modelling	A Folkard
	Fish biology	A Elliott
	Sediments as a record of change	I Winfield
Week 3	Acidification & recovery	P Barker D Monteith
	Methods of sampling lakes: field trip on Windermere	
	Nutrient sources to lakes	I Winfield
Week 4	Trophic interactions & alternative stable states	P Haygarth
Week 5	Multiple stressors & the Water Framework Directive	H Feuchtmayr S Thackeray

Prac/wsp	**Title**	**Lecturer**
Week 1	Phytoplankton and zooplankton observation and ecology	Maberly, Thackeray & Barker
Week 2	Modelling lake responses to external forcing	Elliott
Week 3	Use of high-frequency lake measurements to estimate physical factors & response to climate forcing	Folkard
Week 4		
Week 5	Methods of sampling lakes: field trip to Windermere (as above)	Winfield & Thackeray
	Student presentations	Barker, et al.

***Learning outcomes*:**

On completion of this module a student should be able to:

- Understand the fundamentals of how lakes function
- Understand the tools and approaches needed to study and manage lakes
- Appreciate the complex interplay between external drivers and internal interactions within lakes
- Understand the science underpinning the Water Framework Directive
- Identify the processes leading to nutrient inputs to lakes
- Demonstrate a knowledge of the effects of climate change on lakes
- Identify the factors controlling fish populations
- Understand the potential and limits of state-of-the-art techniques in lake ecology
- Appreciate the principles and uses of lake and catchment modelling

Assessment: CWA: 100%

Details of CWA:

A 4000 word report accounts for 80% of the coursework element and 20% is from a presentation. These skills are essential in preparing students for future careers.

Recommended texts and other learning resources:

Texts: Kalff J. (2002) Limnology: inland water ecosystems. Prentice Hall, New Jersey.
Smol J.P. (2008). Pollution of lakes and rivers: a paleoenvironmental perspective 2nd edn. Blackwell, Malden Mass.
Lampert W. & Sommer U (2007) Limnoecology. The Ecology of Lakes and Streams. Oxford University Press.
Wetzel R.G. (2001) Limnology: Lake & River Ecosystems. 3rd edn. Elsevier.

MODULE NUMBER: LEC.500	**MODULE TITLE: DISSERTATION PROJECT (30 CREDIT)**		
Number of weeks:	*Term taught:* All year	*Contact hours: 40*	*Learning hours:* 300
Pre-requisites: None		*Co-requisites:*	*Credits:* 30
Module organiser: Dr Ian Hartley		***Other lecturers:*** Dr Mike Roberts, Dr Robert Blake, Dr Andrew Jarvis, Dr Chris Sherlock Prof. Barbara Maher	

Aims and scope:
This module, leading to the award of a PG Diploma, is an option for students who due to unforeseen circumstances, may need to curtail their course or for some reason are unable to complete a full-length Masters dissertation project. This module covers the full development, execution and delivery of the dissertation. In addition to the project, a series of 1 hour dissertation support seminars will be given on specific research skills, as detailed below, and assessment will be made at several stages, as outlined below.

Syllabus

Activity	**Convenor**
W1-20	
Introductory seminar	IH
Scientific communication	RB
Data presentation	AJ
Writing scientific papers	MRR
Use of statistics	CS
Writing funding applications	BAM
Endnote for bibliographic referencing	ISS
Preparing Posters using Powerpoint	ISS
W17	
Interim reporting	Supervisor
W28	
LEC Masters poster day	Supervisor
W40	
Dissertation submission	Supervisor

***Learning outcomes*:**
On completion of this module students will be able to:

- Plan, execute and present the findings of a masters level research project
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner
- Produce effective data presentations and use them to enhance the communication of quantitative information
- Understand the requirements of funding applications and how to go about preparing one
- Use standard project management tools in order to deliver to predetermined goals effectively
- Creating, presenting and defending a poster at a scientific meeting

Assessment

Part 1 (formative)
- Interim Report. This four page document will provide an outline of the project and will include its aims and objectives, proposed methods to be used and a detailed project management specification
- Poster Presentation.

Part 2 (summative)
A 5,000 word dissertation

MODULE NUMBER: LEC.501	**MODULE TITLE: DISSERTATION PROJECT**		
Number of weeks:	*Term taught:* All year	*Contact hours: 40*	*Learning hours:* 900
Pre-requisites: None		*Co-requisites:*	*Credits:* 90
Module organiser: Dr Ian Hartley		***Other lecturers:*** Dr Mike Roberts, Dr Robert Blake, Dr Andrew Jarvis, Dr Chris Sherlock Prof. Barbara Maher	

Aims and scope:
This module covers the full development, execution and delivery of the Masters dissertation. In addition to the project, a series of 1 hour dissertation support seminars will be given on specific research skills, as detailed below, and assessment will be made at several stages, as outlined below.

Syllabus

Activity	**Convenor**
W1-20	
Introductory seminar	IH
Scientific communication	RB
Data presentation	AJ
Writing scientific papers	MRR
Use of statistics	CS
Writing funding applications	BAM
Endnote for bibliographic referencing	ISS
Preparing Posters using Powerpoint	ISS
W17	
Interim report	Supervisor
W28	
LEC Masters poster day	Supervisor
W40	
Dissertation submission	Supervisor

***Learning outcomes*:**
On completion of this module students will be able to:

- Plan, execute and present the findings of a masters level research project
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner
- Produce effective data presentations and use them to enhance the communication of quantitative information
- Understand the requirements of funding applications and how to go about preparing one
- Use standard project management tools in order to deliver to predetermined goals effectively
- Creating, presenting and defending a poster at a scientific meeting

Assessment

Part 1 (formative)
- Interim Report. This four page document will provide an outline of the project and will include its aims and objectives, proposed methods to be used and a detailed project management specification
- Poster Presentation.

Part 2 (summative)
A 10,000 word dissertation

MODULE NUMBER: LEC.502	**MODULE TITLE: DISSERTATION PROJECT**		
Number of weeks:	*Term taught:* All year	*Contact hours: 40*	*Learning hours:* 1200
Pre-requisites: None		*Co-requisites:*	*Credits:* 120
Module organiser: Dr Ian Hartley		***Other lecturers:*** Dr Mike Roberts, Dr Robert Blake, Dr Andrew Jarvis, Dr Chris Sherlock Prof. Barbara Maher	

Aims and scope:
This module covers the full development, execution and delivery of the masters dissertation. In addition to the project, a series of 1 hour dissertation support seminars will be given on specific research skills, as detailed below, and assessment will be made at several stages, as outlined below.

Syllabus

Activity	**Convenor**
W1-20	
Introductory seminar	IH
Scientific communication	RB
Data presentation	AJ
Writing scientific papers	MRR
Use of statistics	CS
Writing funding applications	BAM
Endnote for bibliographic referencing	ISS
Preparing Posters using Powerpoint	ISS
W17	
Interim reporting	Supervisor
W28	
LEC Masters poster day	Supervisor
W40	
Dissertation submission	Supervisor

***Learning outcomes*:**
On completion of this module students will be able to:

- Plan, execute and present the findings of a masters level research project
- Write concisely and effectively in order to communicate concepts and ideas in a logical and coherent manner
- Produce effective data presentations and use them to enhance the communication of quantitative information
- Understand the requirements of funding applications and how to go about preparing one
- Use standard project management tools in order to deliver to predetermined goals effectively
- Creating, presenting and defending a poster at a scientific meeting

Assessment

Part 1 (formative)
- Interim Report. This four page document will provide an outline of the project and will include its aims and objectives, proposed methods to be used and a detailed project management specification
- Poster Presentation.

Part 2 (summative)
A 15,000 word dissertation