Imperial College London

Masters in Ecology, Evolution and Conservation

Programme Handbook 2014 – 2015

Department of Biological Sciences, Imperial College London, Silwood Park Campus, Ascot, Berkshire, SL5 7PY, UK

Contents

Along with this handbook, you will receive a copy of the Student Handbook for the Silwood Park Campus, containing the following important information for all living and working at Silwood.

Introduction to the department
: Key contacts and information on the library, IT, safety and seminars.

Academic regulations
: The regulations for the EEC course are provided in this handbook, but the Student Handbook provides information about the general regulations. This includes academic integrity, plagiarism, employment during your studies and complaint and appeals procedures.

Welfare and Advice
: Imperial has a wide support network for students. The Student Handbook provides details of the available support and key contacts and links.

Student Feedback and Representation
: We are very grateful for feedback on the course and will ask you for it at regular intervals! However, there are a range of options for providing feedback and getting support on your academic studies and the Student Handbook provides details.

Electronic copies of both of these handbooks are available on the course Blackboard website.

1 Course structure

Welcome to Silwood Park and the Masters programmes in Ecology, Evolution and Conservation!

The MSc and MRes courses in Ecology, Evolution and Conservation began in 2004 and 2005, and since then have trained over 300 students. Our graduates have gone on to careers in academia, NGOs, consultancy, teaching and many more. The courses are taught by researchers within the Ecology and Evolution section at Imperial College London.

The aim is simple: to teach you how to do excellent science and to apply your science to solve problems concerning the origins and future of life on earth. The emphasis is on learning the skills to become an independent researcher and scientist.

The taught course initially provides core concepts and skills for both courses through lectures, practicals and group-based activities and goes on to provide extended teaching for the MSc programme in a wide range of current topics in ecology, evolution and conservation. The research projects undertaken by students on both courses provide the opportunity to develop a long piece of independent research, based either in a lab within the college or with another institution in the UK or internationally.

1.1 Course overview

Masters Course Director	Dr David Orme
Postgraduate Administrator	Mrs. Amanda Ellis
Postgraduate Tutor	Dr. Andrew Knight
Blackboard e-learning website	http://bb.imperial.ac.uk

The course runs for one year from the 6th October 2014 through to the end of September 2015. The taught components of the courses (lectures and practicals/workshops) typically start at 10.00 and finish by 16.30 but this varies from week to week – details for each week are provided in this handbook and an electronic timetable is provided on Blackboard. Wednesday morning is either used for taught material or reserved for private study and Wednesday afternoon is normally reserved for sports, leisure activities or private study.

In addition to the formal taught and research components of the programme, there are two research seminar series that run at Silwood Park. The first series (running on Mondays 1pm) are internal departmental seminars, presenting research by Imperial PhD students and research staff. The second series (running on Thursdays at 1pm) are external research seminars presented by visiting academics.

Teaching materials and other course materials are provided using the online Blackboard virtual learning environment (see link above). Paper copies of lecture notes and handouts are not normally provided but you will receive printing credit for use during the course on your security card.

It is anticipated that reading and coursework will require additional study in your own time. During research projects, you are expected to work full time on the project, including Wednesday afternoons. Some projects may require out-of-hours work, for example maintaining greenhouse experiments.

The full programme specifications for the MSc and MRes are available on Blackboard and from the course websites below, but the following sections provide a summary of the programme and assessment structure for the two courses. The full aims, objective and learning outcomes for the course are set out in detail in section 2.4.

MSc website
http://www3.imperial.ac.uk/lifesciences/postgraduate/courselist/ecology

MRes website
: http://www3.imperial.ac.uk/lifesciences/postgraduate/courselist/ecologyresearch

1.2 Master of Science programme

Students following the MSc must attend 10 weeks of taught modules in the Autumn Term and a further 7 weeks of taught modules and a two week mini project during the Spring Term. Over this period, students also have to complete four pieces of assessed coursework. MSc students must also attend Thursday afternoon seminars, which will form the basis of questions in essay exams. Attendance at Monday lunchtime seminars is optional. MSc students must also complete a 4 month research project running during the summer from April until September.

Assessment of this work will be based on three examinations (30% of marks), the four pieces of assessed coursework (20%) and the research project performance, report and viva (50%). Students should not skip lectures or practicals to complete coursework. Example exam papers and assessment schemes for exams, coursework and research project are provided on Blackboard. A list of example research project titles is provided at the end of the booklet and final project titles will be established following discussion with supervisors by the 3rd week of Spring Term.

The assessed components and their percentage contribution to your overall mark are described below, along with the *key dates and deadlines* for this year.

1.2.1 Examinations (30% of overall mark)

The examinations are timetabled to follow immediately after the Christmas vacation and two reading weeks dedicated to revision in Term 2. Please note that *all examinations are computer-based*.

January esssay exam (12%)
: This assessment will examine work done during the first 8 weeks of the Autumn term and seminars from the Autumn term. You will have to choose three essay questions out of a choice of nine.

Data interpretation exam (6%)
: You will need to complete two problem-based questions on interpreting data. This paper does not assume any specific taught content, but tests your data interpretation skills when confronted with unfamiliar examples.

Spring essay exam (12%)
: This assessment will follow the format of the January exam, but examine material from the second half of the course (Week 9 onward) and Spring term seminars.

Thu 8th Jan	10:00 – 13:00	January essay exam
Wed 8th Apr	10:00 – 13:00	Spring essay exam
Thu 9th Apr	10:00 – 12:00	Data interpretation exam

1.2.2 Coursework (20% of overall mark)

Habitat Management Poster (5%)
: To conclude the Field Conservation module, you must prepare a poster on the management of one of

the habitats encountered on Chobham Common. The poster should summarise the basic ecology of the habitat and explain to a non-specialist audience, such as a landowners and other stakeholders, why it is important to conserve the habitat and what management strategy you would propose.

You should prepare the poster in an A1 landscape (wider than tall) format and submit it electronically as a pdf file. We will be holding a project assessment session during which you will have to present an 'elevator pitch' in front of a projection of your poster. The elevator pitch is a two minute spoken summary, aimed at stakeholders, that aims to hook their interest in the poster and the topic. You will be assessed on both poster quality and the quality of your pitch.

Grant proposal (5%)

During the Speciation and the evolution of biodiversity module (Week 6), you will work on practicals introducing topics in microbial ecology. Each student will write a two-page (Arial font, minimum 11pt, margins at least 1.5cm) project outline in the style of a grant application. The aim of the proposed project will be to explore further questions resulting from the practical. The proposal should:

a) Introduce the background to the problem, why is this an interesting problem?

b) Present the preliminary findings, i.e. the practical results. What do we know already?

c) Outline the hypotheses to be tested in the proposed project

d) Outline how you would test those ideas, giving brief methodological details.

In real life, a late grant proposal or one not confirming to instructions (e.g. word limits) would not be considered. For this exercise, we will consequently dock marks for late projects or those not confirming to the above limits. You will need to submit it online and hand in a printed copy to Amanda.

Mini-project report (5%)

During the spring term, each student will work independently on a research question using existing data or collecting simple new data and analyse this using basic methods. You will have to present a short written report of up to four pages (+ up to 2 pages with figures) with abstract, introduction, methods, results and discussion. You will need to submit it online and hand in a printed copy to Amanda.

Mini-project presentation (5%)

Each student will give a 10 minute presentation to introduce their mini-project research, explain their methods, show what their findings were, discuss the interpretation and any limitations, and briefly state how they would extend their research with more time and money!

Mon 10th Nov	by 09:00	Chobham Habitat poster hand-in deadline
Wed 12th Nov		Chobham Poster assessment
Mon 8th Dec	by 09:00	Microbial Ecology Grant Proposal hand-in deadline
Fri 13th Mar		Miniproject presentations
Mon 16th Mar	by 09:00	Miniproject hand-in deadline

1.2.3 Research project (50% of overall mark)

Research project performance (10%)

Your project supervisor will assign a grade based on your work over the course of the project, including any field, lab or desk based research as well as how well you worked within a laboratory or group.

Research project report (30%)

The research project must be completed and written up in the style and formatting of a scientific research paper. There will also be an EEC Masters Student Conference across both MSc and MRes programs, where each student will give a 10 minute presentation on their project. Participation is mandatory but not assessed.

Research project viva (10%)

Each student will have a 30 minute viva with two internal examiners and your performance in the viva will contribute to your final mark.

To obtain a pass you must pass all three components (i.e. a mark of 50% or higher). To obtain a Merit you must attain an average mark of 60% or higher, and 60% in at least two of the three components. To obtain Distinction you must attain an average mark of 70% or higher, and 70% in at least two of the three components and none less than 60%. These regulations are set out in more detail in the MSc degree regulations provided in this handbook and on Blackboard.

Mon 13th Apr		Summer Project start
Tue 1st Sep	by 12:00	Summer Project hand-in deadline
Mon 14th Sep		Masters Project Conference
Tue 15th Sep		Summer Project vivas
Wed 16th Sep		Summer Project vivas
Thu 17th Sep		External examiner vivas

1.3 Master of Research programme

Students following the MRes must attend the first 5 weeks of taught modules in the Autumn Term and two further weeks of statistics in the Spring Term. Students may optionally attend additional lectures on the MSc up to a maximum of two extra courses. For students conducting molecular lab projects, one of these two courses should be the Genomics module. Attendance at both Monday lunchtime and Thursday afternoon seminars is compulsory for MRes students, unless you are conducting your project off-site.

MRes students must complete *two* research projects: the Winter project, running between November and March; and the Summer Project, running between April and September. The project write-up and data analysis at the end of the Winter project is intended to link with the Spring statistics course. The projects should be with different supervisors and chosen to represent two of the following general categories:

1. Ecological Modelling and Population Management
2. Bioinformatics and Evolutionary Analysis
3. Molecular Ecology, Phylogenetics and Development (lab component)
4. Ecology, Evolution or Conservation Field Research

Assessment of the MRes is based solely on the two research projects (50% each). The assessed components of each project and their percentage contribution to your overall mark are described below, along with the *key dates and deadlines* for this year.

1.3.1 MRes Project assessment components

Research project performance (10%)

Your project supervisor will assign a grade based on your work over the course of the project, including any field, lab or desk based research as well as how well you worked within a laboratory or group.

Research project report (30%)

The research project must be completed and written up in the style and formatting of a scientific research paper. There will also be an MRes student conference, where each student will give a 10 minute presentation on their project. This is mandatory but not assessed.

Research project viva (10%)

Each student will have a 30 minute viva with two internal examiners and your performance in the viva will contribute to your final mark.

To pass the course, you must pass both projects (i.e. a mark of 50% or higher). To obtain a Merit you must attain an average mark of 60% or higher with both projects passed. To obtain Distinction you must attain an average mark of 70% or higher, with neither project lower than 60%. These regulations are set out in more detail in the MSc degree regulations provided in this handbook and on Blackboard.

1.3.2 MRes Project dates and deadlines

The dates and deadlines for the two projects are:

Mon 10th Nov		MRes Winter Project start
Thu 26th Mar	by 13:00	MRes Winter Project hand-in deadline
Tue 31st Mar		MRes Winter project conference
Wed 1st Apr		MRes Winter Project vivas
Mon 13th Apr		Summer Project start
Tue 1st Sep	by 13:00	Summer Project hand-in deadline
Mon 14th Sep		Masters Project Conference
Tue 15th Sep		Summer Project vivas
Wed 16th Sep		Summer Project vivas
Thu 17th Sep		External examiner vivas

1.4 External vivas and examiners

All students on both the MSc and MRes programme will undertake a final 20 minute viva with one of the External Examiners, to be held between the internal summer project viva and the final meeting of the Board of Examiners. The dates are shown above.

Although the external vivas are mandatory for all students, they *do not* form part of your assessment.

These vivas form a part of both the exam moderation process and oversight of the course by the External Examiners.

The current External Examiners are:

Dr. Martin Genner	University of Bristol
TBA	TBA
TBA	TBA

1.5 Graduation

The postgraduate graduation ceremony for MSc and MRes students will be held in the Royal Albert Hall in South Kensington, London at the start of the following May. The precise dates are available here:

http://www3.imperial.ac.uk/graduation/graduationtimetable

1.6 Submission of work and penalties for late submission

Project reports and written coursework must be handed in to the Postgraduate Administrator and submitted through the Blackboard site as a PDF document. In real life, research reports, grant proposals and other outputs that are submitted late or that do not conform to instructions (e.g. word limits) would not be considered. We will consequently dock marks for late projects, using a standard penalty of 5% per day, and for written work not conforming to the stated requirements.

1.7 Teaching facilities

The majority of teaching will take place in the Hamilton building (and usually in the Fisher lecture Theatre) but the locations of all teaching activities are given in the timetables below and on Blackboard. See the Student Handbook for the Silwood Park Campus for further details on the lecture theatres, teaching labs, IT and Library facilities.

1.8 Teaching Staff

Add 020 759 to extension numbers to phone from external phones.

Prof Miguel Araújo	Biogeography, conservation planning, global change biology, and macroecology (*miguel.araujo@imperial.ac.uk*)
Prof Tim Barraclough	Evolution of species diversity; speciation; asexual evolution; evolution in multi-species systems; experimental evolution. (*ext. 42247, t.barraclough@imperial.ac.uk*)
Dr Tom Bell	Community ecology and microbial ecology (*ext. 42268, thomas.bell@imperial.ac.uk*)
Dr Martin Bidartondo	Evolution and ecology of mycorrhizal symbioses. (*ext. 0208 332 5379, m.bidartondo@imperial.ac.uk*)
Dr Martin Brazeau	The evolution of modern vertebrate anatomy. (*ext. 42254, m.brazeau@imperial.ac.uk*)
Prof Austin Burt	Evolutionary biology of selfish genetic elements; homing endonuclease genes and their applied uses. Population and evolutionary genetics of yeasts. (*ext. 42266, a.burt@imperial.ac.uk*)

Dr Lauren Cator	Understanding the effects of mosquito behavior on interactions and parasite dynamics. (*ext. 41785, l.cator@imperial.ac.uk*)
Dr Rich Gill	Ecologically applied questions; studying the evolution of animal behaviour. (*ext. 42215, r.gill@imperial.ac.uk*)
Dr Helen Hipperson	Molecular genetic techniques in ecology and evolutionary biology (*ext. 41059, h.hipperson@imperial.ac.uk*)
Dr Andrew Knight	Decision-making in conservation planning. (*ext. 42283, andrew.knight1@imperial.ac.uk*)
Dr Igor Lysenko	Biodiversity GIS analyst (*ext. 42211, i.lysenko@imperial.ac.uk*)
Prof EJ Milner-Gulland	Conservation science (*ext. 42509, e.j.milner-gulland@imperial.ac.uk*)
Dr David Orme	Global biodiversity patterns; GIS; conservation and climate change biology (*ext. 42352, d.orme@imperial.ac.uk*)
Dr Samraat Pawar	Scaling of indvidual metabolism through interactions to community- and ecosystem-level dynamics. (*ext. 42213, s.pawar@imperial.ac.uk*)
Prof Colin Prentice	Plant reactions to changes in climate and other aspects of the physical environment (*ext. 42354, c.prentice@imperial.ac.uk*)
Dr Ben Raymond	Applied evolutionary biology of microbes and microbe-host interactions and the evolution and maintenance of cooperation. (*ext. 42363, b.raymond@imperial.ac.uk*)
Prof Vincent Savolainen	Global and regional biodiversity patterns; evolutionary radiations; Speciation genomics; conservation. (*ext. 42374, v.savolainen@imperial.ac.uk*)
Dr Mike Tristem	The evolution of retroelements; molecular biology and phylogenetics. (*ext. 42373, m.tristem@imperial.ac.uk*)
Dr Guy Woodward	Impacts of stressors on aquatic ecosystems (*guy.woodward@imperial.ac.uk*)

1.9 Background reading

These are introductory books plus textbooks to roughly undergraduate level on each subject, suitable for background reading. They will not necessarily be text books for the course, which will deal mainly with the primary literature in journals or advanced books. In addition, see the reading lists provided for specific modules in the descriptions below.

General Biodiversity

Gaston, K. and Spicer, J. 2003. Biodiversity: an Introduction. Blackwell Science. *Primer in biodiversity science*

Wilson, E.O. 1992. The diversity of life. *Inspirational popular but deep introduction.*

Ecology

Townsend, C. R., Begon, M. and Harper, J. 2002. Essentials of Ecology. Blackwell Science. *Concise version of longer, classic undergrad textbook*

Crawley, M.J. 1997 [Ed] Plant Ecology. 2nd Ed. Blackwell Science. Oxford.

Evolution

Ridley, M. 2003. Evolution. Blackwell Science. *Comprehensive but quite long text book*

Stearns, S. and Hoekstra, R. 2000. Evolution: An Introduction. Oxford University Press. *Shorter textbook with more current topics etc.*

Conservation

Dobson, A. 1998. Conservation and Biodiversity. Scientific American Library. *Readable, basic first intro.*
Pullin, A.S. 2002. Conservation Biology. Cambridge University Press. *Textbook focused on more conceptual topics*
Sutherland, W. J. and Hill, D.A. 1995. Managing habitats for conservation. Cambridge University Press. *More practical book as title implies.*

2 Course details and timetables

2.1 Taught course module overview

Autumn term modules		
1	06/10/14 — 10/10/14	Community Ecology and Conservation
2	13/10/14 — 17/10/14	Biodiversity assessment and management
3	20/10/14 — 24/10/14	Global biodiversity conservation and GIS
4	27/10/14 — 31/10/14	Introduction to R and statistics
5	03/11/14 — 07/11/14	Biological computing in R
6	10/11/14 — 14/11/14	Speciation and the evolution of biodiversity
7	17/11/14 — 21/11/14	Conservation economics
8	24/11/14 — 28/11/14	Genomics and bioinformatics
9	01/12/14 — 05/12/14	Genome evolution and selfish genetic elements
10	08/12/14 — 12/12/14	Fungal Biology and Miniproject Introduction
Spring term modules		
15	12/01/15 — 16/01/15	Demography and management
16	19/01/15 — 23/01/15	Biological control and integrated pest management
17	26/01/15 — 30/01/15	Applied evolution and sustainable pest management
18	02/02/15 — 06/02/15	Phylogenetics and Evolution in Deep Time
19	09/02/15 — 13/02/15	Generalised linear modelling
20	16/02/15 — 20/02/15	Further topics in statistics
21	23/02/15 — 27/02/15	Ecology and global change
22	02/03/15 — 06/03/15	Miniprojects
23	09/03/15 — 13/03/15	Miniprojects continued
24	16/03/15 — 20/03/15	Behavioural ecology
25	23/03/15 — 27/03/15	Reading week
26	30/03/15 — 03/04/15	Reading week

2.2 Taught module descriptions

The induction and welcome programme for the EEC Masters courses runs in the first week of time, alongside the first module of the core taught course.

2.2.1 Community Ecology and Conservation

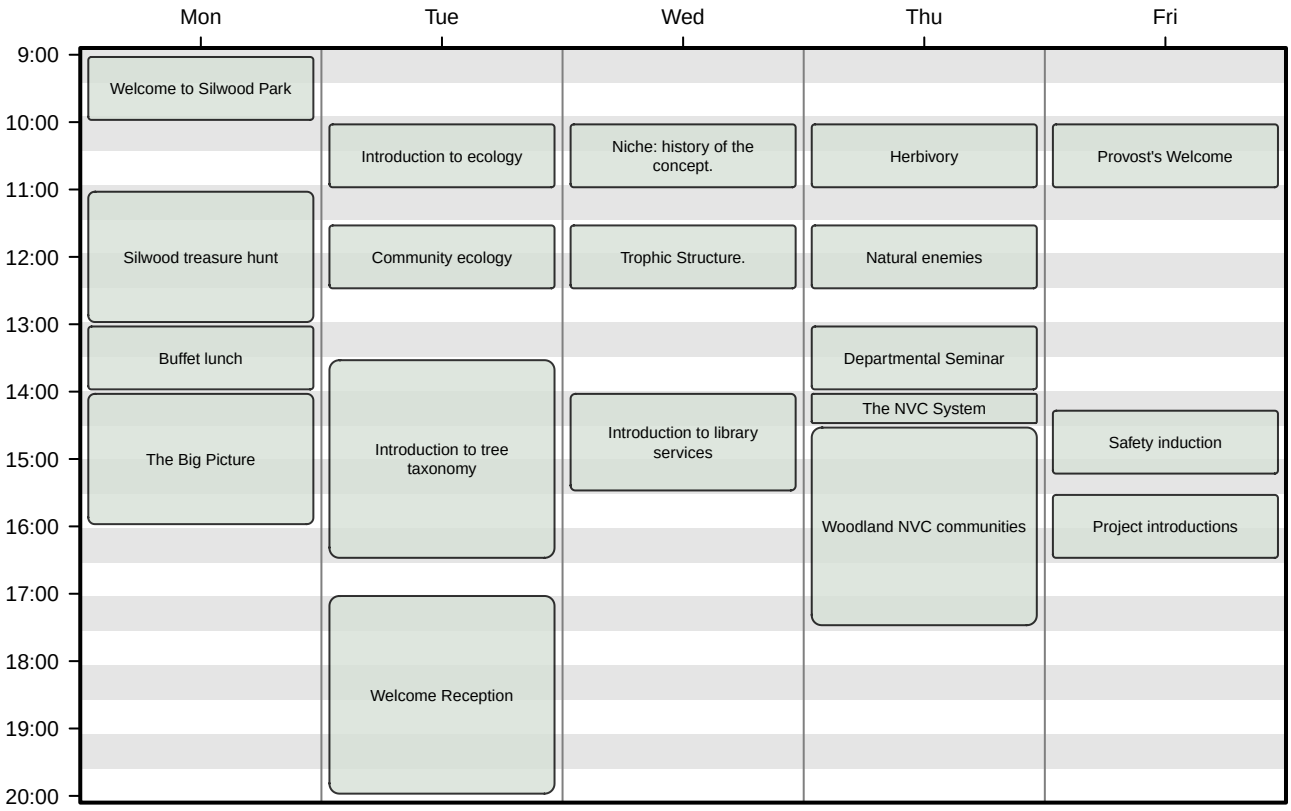
Week: 1 (*Monday 6th October — Friday 10th October*)

Convenor: Tim Barraclough and Ben Raymond

This module focuses on the fundamental processes that determine the distribution and abundance of species. How do ecological processes govern the diversity and stability of communities?

The week also includes a number of important induction events, included in the timetable below.

Timetable:



Monday 6th October	
09:00 — 10:00	*Welcome to Silwood Park* (Induction, Fisher, David Orme)
11:00 — 13:00	*Silwood treasure hunt* (Induction, Silwood Park, David Orme)
13:00 — 14:00	*Buffet lunch* (Induction, Hamilton Foyer)
14:00 — 16:00	*The Big Picture* (Induction, Hamilton Foyer, EJ Milner-Gulland) Discussion Group
Tuesday 7th October	
10:00 — 11:00	*Introduction to ecology* (Lecture, Fisher, Tim Barraclough) What do you know?
11:30 — 12:30	*Community ecology* (Lecture, Fisher, Tim Barraclough) Discrete or continuous variation? Succession and equilibrium
13:30 — 16:30	*Introduction to tree taxonomy* (Field Practical, In front of Manor House, Ben Raymond, Andy Matthews) Habitats of Silwood Park and the tree identification. **Bring raincoats and boots**
17:00 — 20:00	*Welcome Reception* (Induction, Old Library)
Wednesday 8th October	
10:00 — 11:00	*Niche: history of the concept.* (Lecture, Fisher, Tim Barraclough) History of the concept. Formal definitions. Niche in plants and animals. The central role of the Invasion Criterion
11:30 — 12:30	*Trophic Structure.* (Lecture, Fisher, Tim Barraclough) Trophic chains and webs. Oksanen's rule. Diversity and stability. Dominance and relative abundance in communities
14:00 — 15:30	*Introduction to library services* (Induction, Hamilton Computer Room, Elizabeth Killeen)
Thursday 9th October	
10:00 — 11:00	*Herbivory* (Lecture, Fisher, Ben Raymond) The kinds of herbivores and their effects on plant population dynamics.

11:30 — 12:30	*Natural enemies* (Lecture, Fisher, Ben Raymond) Introduction to predators, parasites and diseases and their roles in ecosystem function.
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 14:30	*The NVC System* (Lecture, Fisher, Ben Raymond, Andy Matthews) Introduction to the National Vegetation Classification system
14:30 — 17:30	*Woodland NVC communities* (Field Practical, In front of Manor House, Ben Raymond, Andy Matthews) Classifying woodlands of Silwood Park using the National Vegetation Classification scheme. **Bring raincoats and boots**.
Friday 10th October	
10:00 — 11:00	*Provost's Welcome* (Induction, Haldane, Prof. James Stirling)
14:15 — 15:15	*Safety induction* (Induction, Fisher, Stefan Hoyle)
15:30 — 16:30	*Project introductions* (Induction, Fisher, David Orme)

Reading:

May, R.M. & McLean, A. 2007 Theoretical Ecology. Blackwell Scientific.

Further reading:
Crawley, M. J. & J. E. Harral. 2001. Scale dependence in plant biodiversity. *Science* 291:864-868.
Keane, R. M. & M. J. Crawley. 2002. Exotic plant invasions and the enemy release hypothesis. *Trends in Ecology & Evolution* 17:164-170.
Pacala, S. W. & M. J. Crawley. 1992. Herbivores and Plant Diversity. *Am. Nat.* 140:243-260.

2.2.2 Biodiversity assessment and management

Week: 2 (*Monday 13th October — Friday 17th October*)

Convenor: Andrew Knight

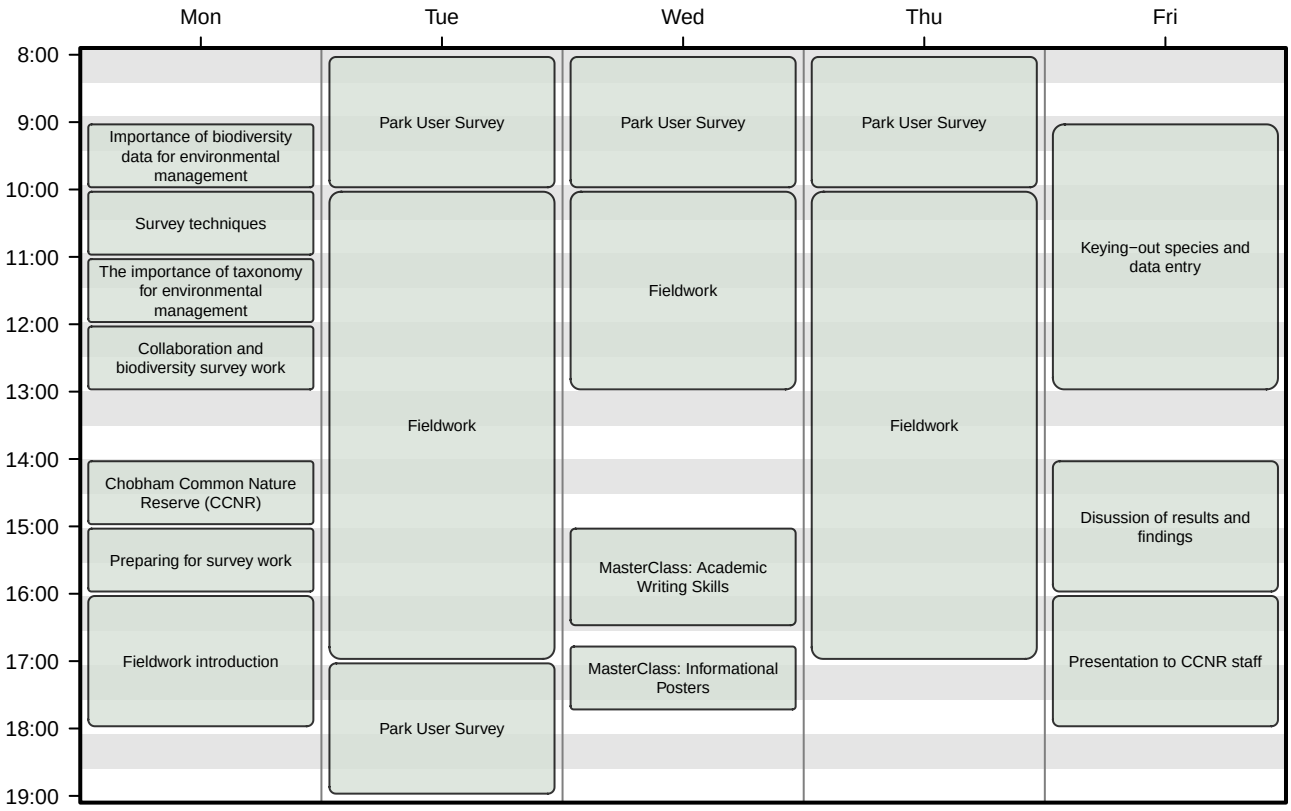
This module will introduce you to a wide range of field survey and assessment skills. The work will be based at the nearby Chobham Common, which is the largest National Nature Reserve in the South East of the UK.

The common is an extremely fine example of a lowland heath, but also includes areas of deep valley bogs, isolated pines and patches of grassland, gorse and silver birch. Mixed broad-leaved and pine woodlands also fringe many of the ponds on the site. You will work alongside local experts from the Surrey Wildlife Trust and from the Natural History Museum to learn survey techniquesacross these habitats and to learn identification skills for a wide range of UK heathland taxa.

Transport to the the common will be by coach, so you will need to follow the timetable below promptly. You will need to bring a packed lunch and a water bottle for Tuesday, Thursday and Friday, when you will spend the day in the field. You must also bring **waterproof boots** - either walking boots or wellingtons - and a **waterproof jacket**, in case we are unlucky with the weather. If we are lucky with the weather, do bring a hat and suntan cream!

The timetable below may change in bad weather as some sampling is either impossible in the rain or may endanger target species, so keep an eye on your email and the BB site for changes.

Timetable:



Monday 13th October	
09:00 — 10:00	*Importance of biodiversity data for environmental management* (Lecture, Haldane, Andrew Knight)
10:00 — 11:00	*Survey techniques* (Lecture, Haldane, Andrew Knight)
11:00 — 12:00	*The importance of taxonomy for environmental management* (Lecture, Haldane, Andrew Knight)
12:00 — 13:00	*Collaboration and biodiversity survey work* (Lecture, Haldane, Andrew Knight)
14:00 — 15:00	*Chobham Common Nature Reserve (CCNR)* (Lecture, Haldane, Steve Fry, Senior Ranger)
15:00 — 16:00	*Preparing for survey work* (Workshop, Haldane, Andrew Knight)
16:00 — 18:00	*Fieldwork introduction* (Field Practical, Chobham Common, Andrew Knight) Reconnaisance of quadrats and pitfall trap locations and Demonstration of field techniques
Tuesday 14th October	
08:00 — 10:00	*Park User Survey* (Field Practical, Chobham Common, Andrew Knight)
10:00 — 17:00	*Fieldwork* (Field Practical, Chobham Common, Andrew Knight)
17:00 — 19:00	*Park User Survey* (Field Practical, Chobham Common, Andrew Knight)
Wednesday 15th October	
08:00 — 10:00	*Park User Survey* (Field Practical, Chobham Common, Andrew Knight)
10:00 — 13:00	*Fieldwork* (Field Practical, Chobham Common, Andrew Knight)
15:00 — 16:30	*MasterClass: Academic Writing Skills* (Workshop, Haldane, Graduate School) This workshop is provided by the Graduate School and you may need to reserve a place on the course through their website.

16:45 — 17:45 *MasterClass: Informational Posters* (Workshop, Haldane, Graduate School) This workshop is provided by the Graduate School and you may need to reserve a place on the course through their website.

Thursday 16th October

08:00 — 10:00 *Park User Survey* (Field Practical, Chobham Common, Andrew Knight)

10:00 — 17:00 *Fieldwork* (Field Practical, Chobham Common, Andrew Knight)

Friday 17th October

09:00 — 13:00 *Keying-out species and data entry* (Lab practical, Hamilton Field Lab, Andrew Knight)

14:00 — 16:00 *Disussion of results and findings* (Discussion, Haldane, Andrew Knight)

16:00 — 18:00 *Presentation to CCNR staff* (Workshop, Haldane, Andrew Knight)

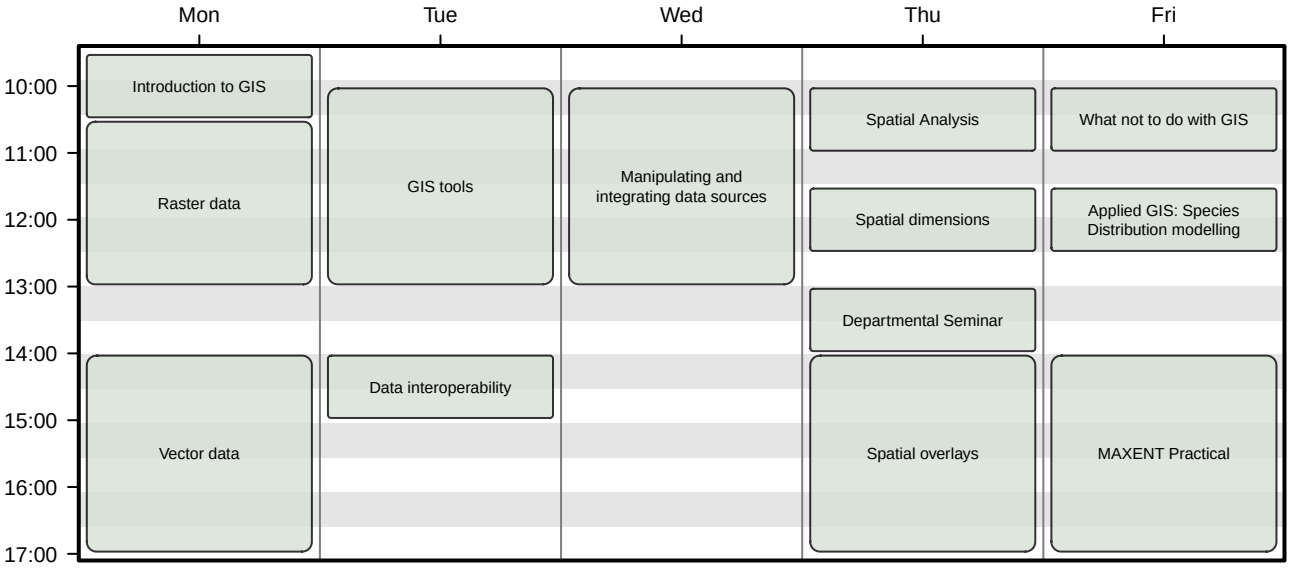
2.2.3 Global biodiversity conservation and GIS

Week: 3 (*Monday 20th October — Friday 24th October*)

Convenor: David Orme and Igor Lysenko

This week will teach key skills in using and handling GIS data, along with the application of GIS data in species distribution modelling. We will use the open source GIS program QGIS along with the species distribution modelling software MAXENT. We will look at creating and georeferencing both vector and raster data and how to use GIS tools to create a workflow to carry out simple analyses.

Timetable:



Monday 20th October

09:30 — 10:30 *Introduction to GIS* (Lecture, Fisher, David Orme) The main concepts and data types underlying Geographic Information Systems.

10:30 — 13:00 *Raster data* (Computer Practical, Hamilton Computer Room, David Orme, Igor Lysenko) Handling raster data

14:00 — 17:00 *Vector data* (Computer Practical, Hamilton Computer Room, David Orme, Igor Lysenko) Creating and using vector data

Tuesday 21st October

10:00 — 13:00	*GIS tools* (Computer Practical, Hamilton Computer Room, David Orme, Igor Lysenko) Using GIS commands
14:00 — 15:00	*Data interoperability* (Lecture, Fisher, Igor Lysenko) Sources, format and interoperability
Wednesday 22nd October	
10:00 — 13:00	*Manipulating and integrating data sources* (Computer Practical, Hamilton Computer Room, David Orme, Igor Lysenko) Data acquisition, format conversion and exchange
Thursday 23rd October	
10:00 — 11:00	*Spatial Analysis* (Lecture, Fisher, Igor Lysenko) Great opportunities gaps and traps
11:30 — 12:30	*Spatial dimensions* (Lecture, Fisher, Igor Lysenko) Spatial overlays and data extraction
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Spatial overlays* (Computer Practical, Hamilton Computer Room, David Orme, Igor Lysenko)
Friday 24th October	
10:00 — 11:00	*What not to do with GIS* (Lecture, Fisher, Igor Lysenko) Pitfalls and time sinks
11:30 — 12:30	*Applied GIS: Species Distribution modelling* (Lecture, Fisher, Sarah Whitmee) Using environmental niche models to predict the potential distribution of species.
14:00 — 17:00	*MAXENT Practical* (Computer Practical, Hamilton Computer Room, Sarah Whitmee) Practical introduction to using MAXENT for niche distribution models.

Reading:

GIS overview:
Longley, PA (2011) Geographical information systems and science. Wiley.

Coordinate systems:
Van Sickle, G (2010) Basic GIS coordinates. CRC Press
https://www.dawsonera.com/abstract/9781420092325

2.2.4 Introduction to R and statistics

Week: 4 (*Monday 27th October — Friday 31st October*)

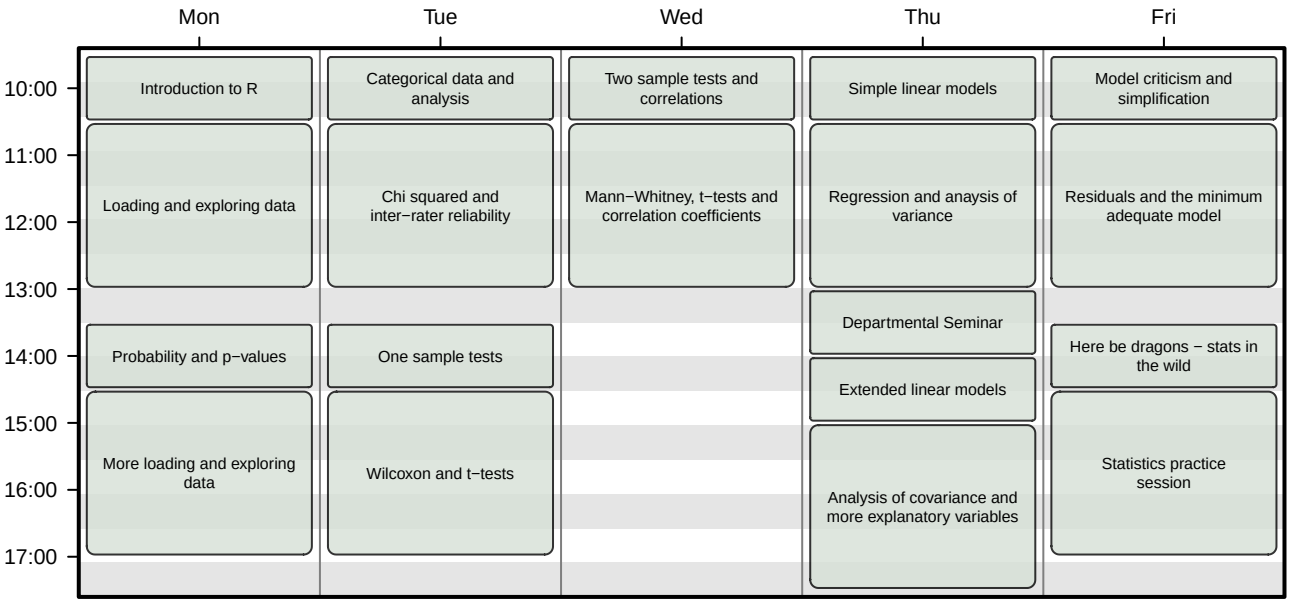
Convenor: David Orme

In this module, we will introduce the use of the open source statistical program R for research and to review a core set of statistical methods that are of wide use in research projects.

We will cover the:

1. the difference between response and explanatory variables and between ordinal, categorical and continuous variables;
2. the underlying structure of statistical testing using both parametric and non-parametric appraoches;
3. tests for assessing differences between samples and correlation between samples;
4. anlaysis of categorical data;
5. and fitting and assessing linear models of continuous response variables.

Timetable:



Monday 27th October

09:30 — 10:30 *Introduction to R* (Lecture, Fisher, David Orme)
10:30 — 13:00 *Loading and exploring data* (Computer Practical, Hamilton Computer Room, David Orme)
13:30 — 14:30 *Probability and p-values* (Lecture, Fisher, David Orme)
14:30 — 17:00 *More loading and exploring data* (Computer Practical, Hamilton Computer Room, David Orme)

Tuesday 28th October

09:30 — 10:30 *Categorical data and analysis* (Lecture, Fisher, David Orme)
10:30 — 13:00 *Chi squared and inter-rater reliability* (Computer Practical, Hamilton Computer Room, David Orme)
13:30 — 14:30 *One sample tests* (Lecture, Fisher, David Orme)
14:30 — 17:00 *Wilcoxon and t-tests* (Computer Practical, Hamilton Computer Room, David Orme)

Wednesday 29th October

09:30 — 10:30 *Two sample tests and correlations* (Lecture, Fisher, David Orme)
10:30 — 13:00 *Mann-Whitney, t-tests and correlation coefficients* (Computer Practical, Hamilton Computer Room, David Orme)

Thursday 30th October

09:30 — 10:30 *Simple linear models* (Lecture, Fisher, David Orme)
10:30 — 13:00 *Regression and anaysis of variance* (Computer Practical, Hamilton Computer Room, David Orme)
13:00 — 14:00 *Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 15:00 *Extended linear models* (Lecture, Fisher, David Orme)
15:00 — 17:30 *Analysis of covariance and more explanatory variables* (Computer Practical, Hamilton Computer Room, David Orme)

Friday 31st October

09:30 — 10:30 *Model criticism and simplification* (Lecture, Fisher, David Orme)
10:30 — 13:00 *Residuals and the minimum adequate model* (Computer Practical, Hamilton Computer Room, David Orme)
13:30 — 14:30 *Here be dragons - stats in the wild* (Lecture, Fisher, David Orme)
14:30 — 17:00 *Statistics practice session* (Computer Practical, Hamilton Computer Room, David Orme)

Reading:

There are a wide range of introductory books for R. See later statistics and computing modules for more specialist texts but, for this week, the following are good introductory and reference texts that are available in Silwood library and as an e-book through Imperial:

Crawley, Michael J (2012) *Statistics: An Introduction Using R.* John Wiley.
http://imperial.eblib.com/patron/FullRecord.aspx?p=827080.

Beckerman, Andrew P. and Petchey, Owen (2012) *Getting Started with R : An introduction for biologists* Oxford University Press.
http://imperial.eblib.com/patron/FullRecord.aspx?p=886478.

A more general reference text for R:

Crawley, MJ (2012) *The R Book*. John Wiley.
http://imperial.eblib.com/patron/FullRecord.aspx?p=1120574.

2.2.5 Biological computing in R

Week: 5 (*Monday 3rd November — Friday 7th November*)

Convenor: Samraat Pawar

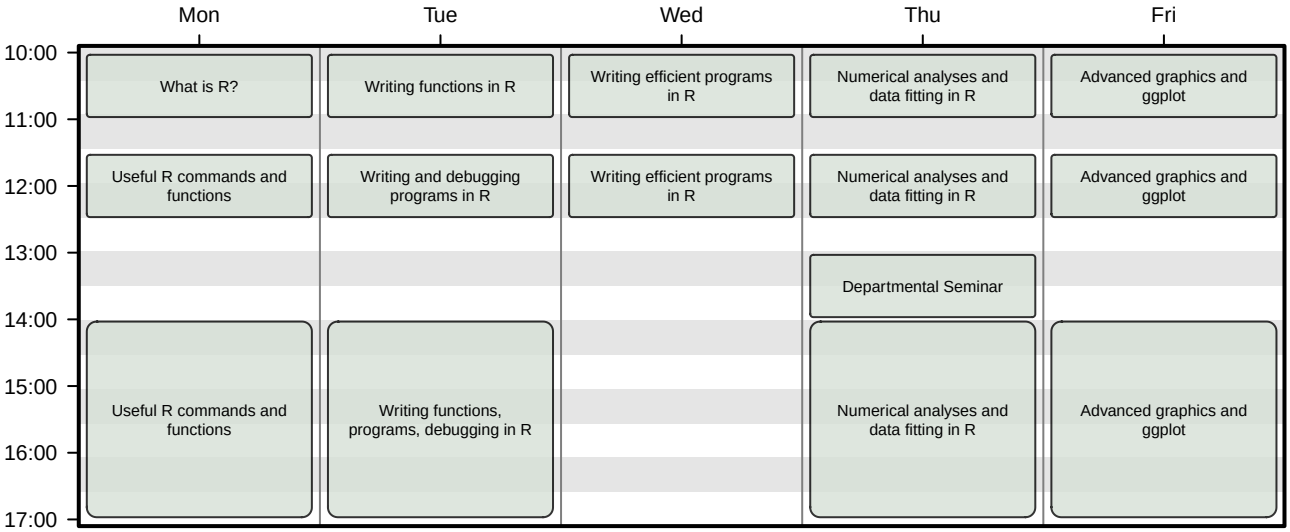
In this module, we will build upon the introduction to R you received in the *Introduction to R and statistics* to learn how to use this freely available statistical software with strong programming capabilities. R has become tremendously popular in Biology due to several factors:

1. many packages are available to perform all sorts of statistical and mathematical analysis;
2. it can produce beautiful graphics;
3. it has a very good support for matrix-algebra.

Being able to program R along with something like Python means you will have am expanded and versatile suite of biological computing tools at your fingertips, especially for automating statistical analysis and the generation of figures. Therefore, R should become an indispensable component of your biological research work flow.

Aims:
To learn how to use R for tasks ranging from data exploration and visualization to producing publication quality graphics. To learn R data types and structures and control flows. To learn how to write and debug efficient R scripts and functions. Learn how to use R packages, and generate elegant graphics.

Timetable:



Monday 3rd November

10:00 — 11:00 *What is R?* (Lecture, Hamilton Computer room, Samraat Pawar)

11:30 — 12:30 *Useful R commands and functions* (Lecture, Hamilton Computer room, Samraat Pawar)

14:00 — 17:00 *Useful R commands and functions* (Computer Practical, Hamilton Computer room, Samraat Pawar)

Tuesday 4th November

10:00 — 11:00 *Writing functions in R* (Lecture, Hamilton Computer room, Samraat Pawar)

11:30 — 12:30 *Writing and debugging programs in R* (Lecture, Hamilton Computer room, Samraat Pawar)

14:00 — 17:00 *Writing functions, programs, debugging in R* (Computer Practical, Hamilton Computer room, Samraat Pawar)

Wednesday 5th November

10:00 — 11:00 *Writing efficient programs in R* (Lecture, Hamilton Computer room, Samraat Pawar)

11:30 — 12:30 *Writing efficient programs in R* (Lecture, Hamilton Computer room, Samraat Pawar)

Thursday 6th November

10:00 — 11:00 *Numerical analyses and data fitting in R* (Lecture, Hamilton Computer room, Samraat Pawar)

11:30 — 12:30 *Numerical analyses and data fitting in R* (Lecture, Hamilton Computer room, Samraat Pawar)

13:00 — 14:00 *Departmental Seminar* (Lecture, Haldane, Visiting staff)

14:00 — 17:00 *Numerical analyses and data fitting in R* (Computer Practical, Hamilton Computer room, Samraat Pawar)

Friday 7th November

10:00 — 11:00 *Advanced graphics and ggplot* (Lecture, Hamilton Computer room, Samraat Pawar)

11:30 — 12:30 *Advanced graphics and ggplot* (Lecture, Hamilton Computer room, Samraat Pawar)

14:00 — 17:00 *Advanced graphics and ggplot* (Computer Practical, Hamilton Computer room, Samraat Pawar)

Reading:

The Use R! series (the yellow books) by Springer are really good. In particular, consider: 'A Beginner's Guide to R', 'R by Example', 'Numerical Ecology With R'', 'ggplot2' (we'll see this in another week), 'A Primer of Ecology with R', 'Nonlinear Regression with R', 'Analysis of Phylogenetics and Evolution with R'. Ben

Bolker's 'Ecological Models and Data in R' is also very good.

For more focus on dynamical models: Soetaert & Herman. 2009 'A practical guide to ecological modelling: using R as a simulation platform'.

There are excellent websites: besides cran (containing all sorts of guides and manuals, you should check out www.statmethods.net, the R graph gallery and the R programming wikibook.

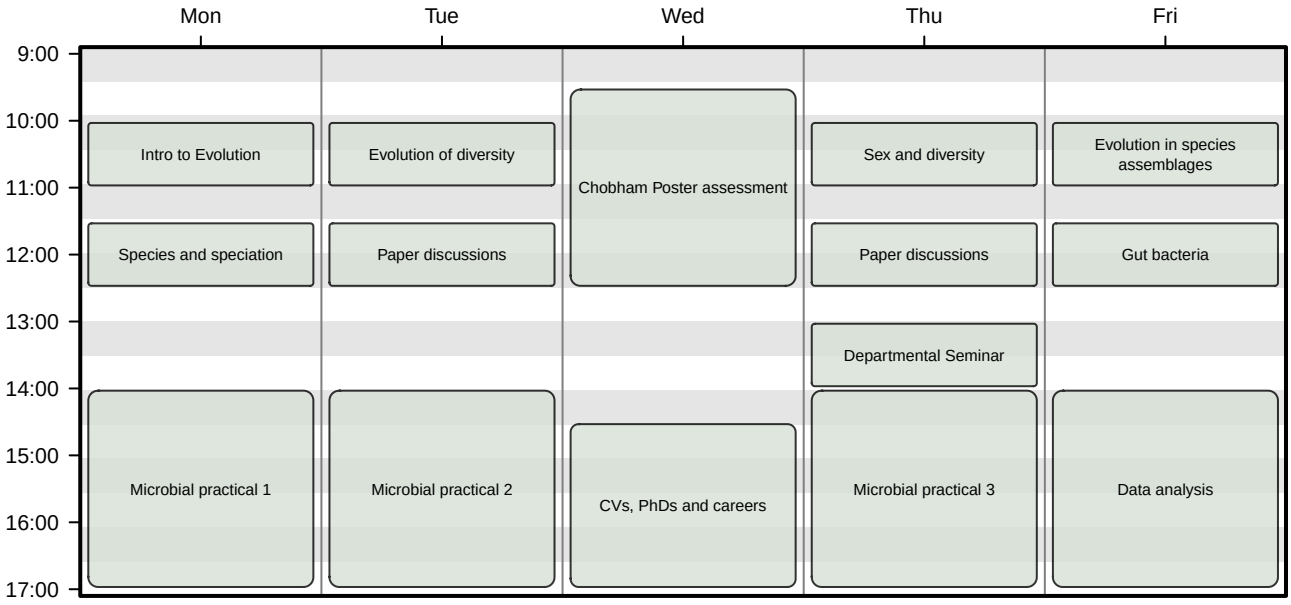
2.2.6 Speciation and the evolution of biodiversity

Week: 6 (*Monday 10th November — Friday 14th November*)

Convenor: Tim Barraclough and Tom Bell

Our planet is home to a bewildering diversity of organisms. Understanding the evolutionary processes behind the origins of biodiversity is fundamental for explaining diversity patterns. We will explore recent advances in research on speciation, the creative force behind the origin of new species, and on how speciation and other processes shape the diversity of different organisms. The last day considers how species evolve in complex communities – a neglected topic of evolutionary biology.

Timetable:



Monday 10th November	
09:00 — 10:00	*MRes Winter Project start* (Projects)
09:00 — 10:00	*Chobham Habitat poster hand-in deadline* (Coursework) By 09:00
10:00 — 11:00	*Intro to Evolution* (Lecture, Fisher, Tim Barraclough) Overview of current evolution research; selection experiments; population genetics; genomics; phylogenetics; evolution in the real world.
11:30 — 12:30	*Species and speciation* (Lecture, Fisher, Tim Barraclough) What are species? Theoretical and practical issues behind species concepts; methods for delimiting species; causes of speciation.
14:00 — 17:00	*Microbial practical 1* (Lab practical, Hamilton Field Lab, Tom Bell)
Tuesday 11th November	

10:00 — 11:00	*Evolution of diversity* (Lecture, Fisher, Tim Barraclough) Evolutionary processes behind diversity patterns, why are there so many species in some groups of organisms and in some places?
11:30 — 12:30	*Paper discussions* (Discussion, Fisher, Tim Barraclough)
14:00 — 17:00	*Microbial practical 2* (Lab practical, Hamilton Field Lab, Tom Bell)
Wednesday 12th November	
09:30 — 12:30	*Chobham Poster assessment* (Coursework, Fisher)
14:30 — 17:00	*CVs, PhDs and careers* (Workshop, Fisher, Course Directors) Specific advice on PhD applications and small group advice on CV and job applications.
Thursday 13th November	
10:00 — 11:00	*Sex and diversity* (Lecture, Fisher, Tim Barraclough) Speciation in an ancient asexual clade of animals, the bdelloid rotifers.
11:30 — 12:30	*Paper discussions* (Lecture, Fisher, Tim Barraclough)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Microbial practical 3* (Lab practical, Hamilton Field Lab, Tom Bell)
Friday 14th November	
10:00 — 11:00	*Evolution in species assemblages* (Lecture, Fisher, Tim Barraclough)
11:30 — 12:30	*Gut bacteria* (Lecture, Fisher, Tim Barraclough)
14:00 — 17:00	*Data analysis* (Computer Practical, Hamilton Computer Room, Tom Bell)

Reading:

Coyne, J. & Orr, H. A. 2004. Speciation. Sinauer.
Purvis, A. & Hector, A. 2000. Getting the measure of biodiversity. Nature. 495: 212-219.
Wilson, E.O. 1992. The diversity of life. *Inspirational, popular but deep introduction.*

2.2.7 Conservation economics

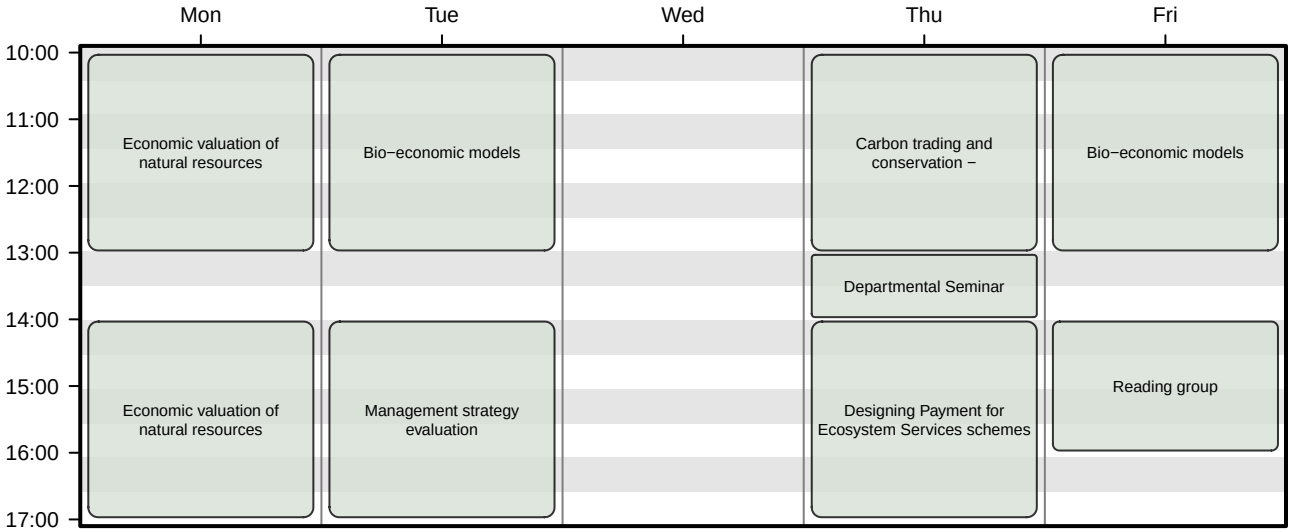
Week: 7 (*Monday 17th November — Friday 21st November*)

Convenor: EJ Milner-Gulland

This module will explore a range of topics covering the impact of economic constraints on the implementation of good conservation practice.

It is taught jointly with the Conservation Science MSc.

Timetable:



Monday 17th November

10:00 — 13:00 *Economic valuation of natural resources* (Lecture, Haldane, Susana Mourato) This one-day session provides an introduction to a key field of study of modern environmental economics: the field of environmental valuation, which is concerned with uncovering the economic value of non-market changes in natural resources.

The session will start by exploring the rationale for environmental valuation and reviewing its main policy uses. It will then introduce some key economic valuation techniques for natural resource valuation – with a focus on the travel cost method, the hedonic price method, the contingent valuation method and choice experiments – and discuss their usefulness and limitations. Examples and case studies will be used extensively to illustrate how the techniques presented can aid decision-making in the conservation sector.

Having discussed the economic value of environmental assets and how it can be measured, the session will conclude with an introduction to innovative market-based mechanisms by which these values can be captured and transformed into actual cash flows. Such mechanisms can provide powerful incentives and efficient means of protecting the environment, while at the same time, creating new sources of finance to low-income communities. Examples are systems of payments for environmental services, eco-tourism, eco-labelling, bio-prospecting and debt-for-nature swaps.

14:00 — 17:00 *Economic valuation of natural resources* (Lecture, Haldane, Susana Mourato) See above

Tuesday 18th November

10:00 — 13:00 *Bio-economic models* (Lecture, Haldane, EJ Milner-Gulland) We explore the economics of renewable resource harvesting. We link a simple model of population growth with a model of profitability to create a bioeconomic model. The model produces some policy recommendations for ensuring harvesting is sustainable. We then look at how market structure affects sustain ability. On Friday, we will build some simple models of harvesting in Excel, and generate some of the graphs that we discussed in the morning.

14:00 — 17:00 *Management strategy evaluation* (Lecture, Haldane, EJ Milner-Gulland) MSE is a technique that has been widely used in fisheries for the last few years. We are now starting to apply it to conservation problems as well. In this session I explain what MSE is, how it works, and give some examples of its application.

Thursday 20th November	
10:00 — 13:00	*Carbon trading and conservation* - (Lecture, Haldane, Christian de Vaal)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Designing Payment for Ecosystem Services schemes* (Lecture, Haldane, Nick Hanley) In this lecture, we will look at the basic design problems that PES schemes need to solve, and what economic insights are available into how best to come up with good solutions. PES schemes involve voluntary transactions between sellers and buyers which aim to increase the supply of ecosystem services such as flood protection or carbon sequestration, and/or which aim to achieve nature conservation goals, through protecting habitats and species. We mainly analyse such schemes in terms of the economic incentives they establish for land managers and land users. Some of the important design problems revolve around "missing information". Some revolve around spatial variation in the relationships between land use, land management and ecosystem service supply. Practical examples will be provided from the UK uplands, Tanzania, Ethiopia and Cambodia. Finally, we also look at how estimating the economic benefits of ecosystem services or biodiversity conservation can improve policy design.
Friday 21st November	
10:00 — 13:00	*Bio-economic models* (Computer Practical, Hamilton Computer Room, EJ Milner-Gulland)
14:00 — 16:00	*Reading group* (Discussion, Haldane, EJ Milner-Gulland)

Reading:

Key text:
Milner-Gulland, E.J. & Rowcliffe, M. (2007) Conservation and sustainable use: A handbook of techniques. Oxford University Press.

Additional texts on the economics of exploitation:
Clark, C.W. (1990) Mathematical Bioeconomics. 2nd Edn. Wiley Interscience. Chapter 2.
Pearce, D.W.and Turner, R.K. (1990) Economics of Natural Resources and the Environment. Harvester Wheatsheef. Chapter 16.
Hardin, G. (1968) The tragedy of the commons. Science 162, 1243-1247.

Additional texts on economics and conservation:
Edward-Jones, G., Davies, B. and Hussein, S. 2000 Ecological Economics. Oxford: Blackwells.Pearce, D., Atkinson, G. & Mourato, S. (2006). Cost Benefit Analysis and the Environment: Recent Developments.
Bunnefeld et al. (2011) Management Strategy Evaluation: A powerful tool for conservation? *Trends in Ecology and Evolution* 26, 441-447
Hanley N, Banerjee S., Lennox G, and Armsworth P. (2012) How should we incentivise private landowners to produce more biodiversity? *Oxford Review of Economic Policy*, 28 (1), 93-113

2.2.8 Genomics and bioinformatics

Week: 8 (*Monday 24th November — Friday 28th November*)

Convenor: Helen Hipperson and Vincent Savolainen

Aims:
There have been formidable developments in genomics technologies (e.g. next generation DNA sequenc-

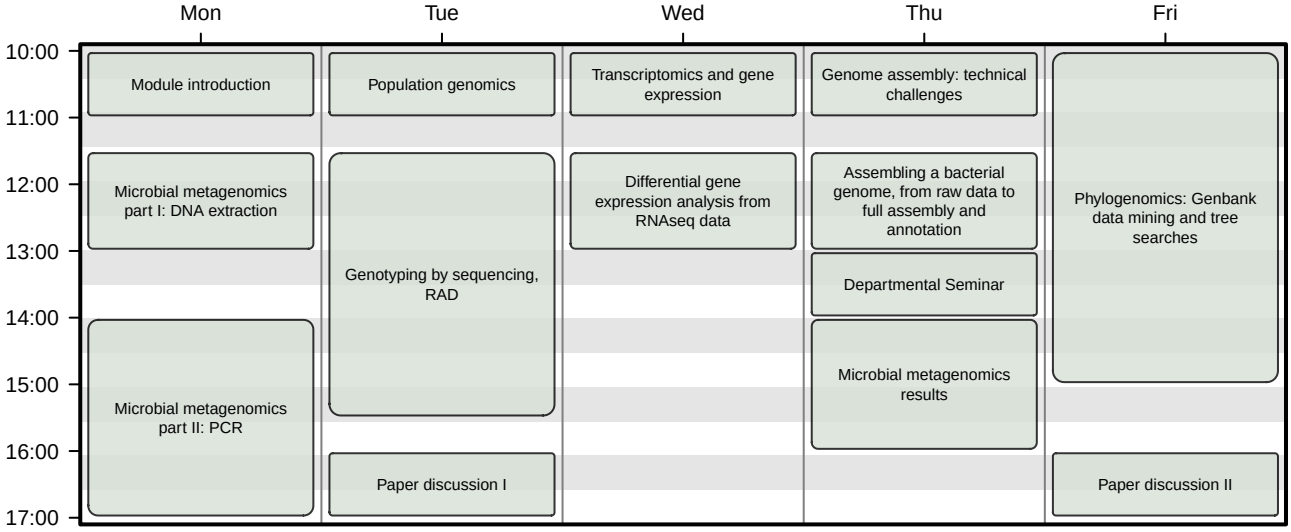
ing), as well as a dramatic increase in the use of DNA data in biodiversity research over the past several years. In addition to analyses of population genomics, gene expression, phylogenetics, etc., DNA-based techniques are now routinely used in areas such as taxon identification, conservation assessments and biodiversity monitoring. The aim of the course will be to introduce basic molecular biology techniques in the laboratory, and a series of lectures and computer exercises will also introduce the students to some common topics and analyses (data formats and computational methods) to give an overview of the latest developments in biodiversity genomics.

Learning outcomes:

1. Fluency in basic molecular laboratory work.
2. An understanding of DNA sequencing techniques and technologies.
3. Ability to manipulate and analyse genomic data.
4. An understanding of the relevance of genomics data and techniques for research in biodiversity, ecology, evolution, conservation and environmental sciences.

The format for the week will be as follows. Each day will run around one of the research areas in genomics. Each day will usually comprise a lecture about the topic, and laboratory (Monday) or computing practicals. We will also discuss papers related to genomics from one of the top science journals (Nature, Science, Cell, PNAS, etc). The paper discussions will be guided by a series of questions given to the students the day before. Teaching activities are scheduled from 10.00am until 5.00pm, except Wednesday afternoon.

Timetable:



Monday 24th November	
10:00 — 11:00	*Module introduction* (Lecture, Fisher, Helen Hipperson) Introduction to the week, overview of genomics techniques and introduction to the lab practical
11:30 — 13:00	*Microbial metagenomics part I: DNA extraction* (Lab Practical, Hamilton Teaching Lab, Helen Hipperson)
14:00 — 17:00	*Microbial metagenomics part II: PCR* (Lab Practical, Hamilton Teaching Lab, Helen Hipperson)
Tuesday 25th November	
10:00 — 11:00	*Population genomics* (Lecture, Fisher, Helen Hipperson)
11:30 — 15:30	*Genotyping by sequencing, RAD* (Computer Practical, Hamilton Computer Room, Helen Hipperson)
16:00 — 17:00	*Paper discussion I* (Discussion, Fisher, Helen Hipperson)

Wednesday 26th November	
10:00 — 11:00	*Transcriptomics and gene expression* (Lecture, Helen Hipperson, Luke Dunning)
11:30 — 13:00	*Differential gene expression analysis from RNAseq data* (Computer Practical, Hamilton Computer Room, Helen Hipperson, Luke Dunning)
Thursday 27th November	
10:00 — 11:00	*Genome assembly: technical challenges* (Lecture, Fisher, Helen Hipperson)
11:30 — 13:00	*Assembling a bacterial genome, from raw data to full assembly and annotation* (Computer Practical, Hamilton Computer Room, Xueping Quan)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 16:00	*Microbial metagenomics results* (Computer Practical, Hamilton Computer Room, Helen Hipperson)
Friday 28th November	
10:00 — 15:00	*Phylogenomics: Genbank data mining and tree searches* (Computer Practical, Hamilton Computer Room, Benjamin Linard, Andrew Briscoe) An essential step in genomic analysis is to combine newly acquired data to the knowledge previously generated by the scientific community. The practical will demonstrate the process of data integration by building a small bioinformatic pipeline which can be regularly executed to update your results with the latest available data. All necessary elements will be built into a small bioinformatic pipeline for retrieving, selecting and aligning genomic sequence data to constantly generate an updated phylogenetic tree. The following concepts will be introduced: • Differences between generalist and specialized databases. • Querying the NCBI database from a script. • Problems of IDs equivalence between the databases. • Importance of conventions and traceability of DNA sequences. • Putting redundant operations in a small script. • Launching other programs (aligners/tree construction) from a script. • Keeping track of the new data generated by the community with such script.
16:00 — 17:00	*Paper discussion II* (Discussion, Fisher, Helen Hipperson)

Reading:

Provisional papers for discussion

1. The Heliconious genome consortium (2012) Butterfly genome reveals promiscuous exchange of mimicry adaptations among species. *Nature* 487:94–98.
2. Scally et al (2012) Insights into hominid evolution from the gorilla genome sequence. *Nature* 483:169–175.

General reading

Stapley et al (2010) Adaptation genomics: the next generation. *TREE* 25:705–12.
Ekblom & Galindo (2011) Applications of next generation sequencing in molecular ecology of non-model organisms. *Heredity* 107:1–15.
Savolainen et al (2013) Ecological genomics of local adaptation. *Nature Reviews Genetics* 14:807–20.

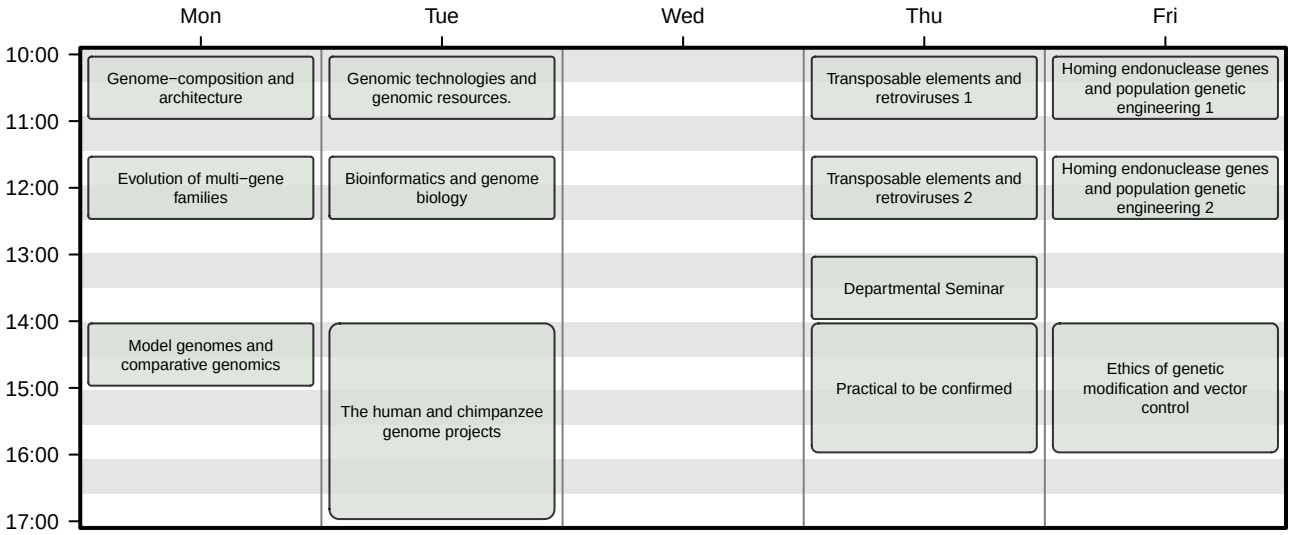
2.2.9 Genome evolution and selfish genetic elements

Week: 9 (*Monday 1st December — Friday 5th December*)

Convenor: Mike Tristem and Austin Burt

This module investigates genomes and genome evolution. The first half concentrates on bioinformatic approaches to deal with the huge amounts of sequence data being generated. The second half looks at the evolutionary biology of a particularly interesting category of genes, namely selfish genetic elements that are inherited in a biased manner. This will include a discussion of their possible application in combating human vector-borne diseases.

Timetable:



Monday 1st December

10:00 — 11:00 *Genome-composition and architecture* (Lecture, Fisher, Mike Tristem) Genome size and the C-value paradox, genome organisation, highly repetitive DNA, mini and micro satellites, selfish genetic elements and their contribution to total genome size. Evolution of non-genic and repetitive DNA, change in genome size via ploypoidy, chromosomal duplication, replication slippage, unequal crossing over, transposition and other mechanisms, origin and evolution of introns.

11:30 — 12:30 *Evolution of multi-gene families* (Lecture, Fisher, Mike Tristem) Evolution of dispersed and tandemly repeated gene families. Gene duplication, gene conversion and concerted evolution, evolution of globins, rDNA genes and hox genes, evolution and detection of pseudogenes.

14:00 — 15:00 *Model genomes and comparative genomics* (Lecture, Fisher, Mike Tristem) Model bacterial and eukaryotic genomes. Origin of life, "evolution of the minimum genome". Uses and applications of comparative genomics.

Tuesday 2nd December

10:00 — 11:00 *Genomic technologies and genomic resources.* (Lecture, Fisher, Mike Tristem) DNA microarrays and gene expression, SNPs and genotyping, proteomics, detecting genetic variation in humans, population markers, pharmacogenomics, Genomic resources, the nature and types of genomic information, the human genome project and its associated databases, genetic maps, cytogenetic maps, morbidity maps, OMIM, Unigene.

11:30 — 12:30 *Bioinformatics and genome biology* (Lecture, Fisher, Mike Tristem) Genomic scale sequencing and assembly (Sanger sequencing, BACS and YACS, automated sequencers, components and contigs), completed and ongoing genome projects, data mining tools, BLAST, FASTA.

14:00 — 17:00	*The human and chimpanzee genome projects* (Computer Practical, Hamilton Computer Room, Mike Tristem) Bioinformatics based practical that will investigate (and then compare and contrast) the human and chimpanzee genome projects at NCBI and ENSEMBL. The practical will include the use of BLAST, map options, and Locuslink to obtain information on specific genes in the human database.
Thursday 4th December	
10:00 — 11:00	*Transposable elements and retroviruses 1* (Lecture, Fisher, Mike Tristem)
11:30 — 12:30	*Transposable elements and retroviruses 2* (Lecture, Fisher, Mike Tristem)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 16:00	*Practical to be confirmed* (Computer Practical, Hamilton Computer Room, Mike Tristem) To be confirmed
Friday 5th December	
10:00 — 11:00	*Homing endonuclease genes and population genetic engineering 1* (Lecture, Fisher, Austin Burt) Homing endonuclease genes (HEGs) are a particularly simple class of selfish genetic element. The potential use of these genes for controlling insect pests will be described, followed by a discussion about the pros and cons of this approach.
11:30 — 12:30	*Homing endonuclease genes and population genetic engineering 2* (Lecture, Fisher, Austin Burt)
14:00 — 16:00	*Ethics of genetic modification and vector control* (Discussion, Fisher, Austin Burt)

Reading:

Lesk, A. M. 2002. Introduction to bioinformatics. Oxford University Press.
Orengo, C. 2003. Bioinformatics: genes, proteins and computers. Oxford
Belshaw, R., V. Pereira, A. Katzourakis, G. Talbot, J. Paces, A. Burt, and M. Tristem. 2004. Long-term reinfection of the human genome by endogenous retroviruses. *PNAS* 101:4894-4849.
Human Genome Consortium. 2001. Initial sequencing and analysis of the human genome. *Nature*. 409:860-921.
Page, R. D. M. & E. C. Holmes. 1998. Molecular evolution: A phylogenetic approach. Blackwell, Oxford.
Burt, A. & Trivers, R. 1006. Genes in Conflict. Harvard University press. Cambridge, Mass.
Camacho, J.P.M. (Ed.) 2004. B Chromosomes in the Eukaryote Genome. Karger, Basel.
Futuyma, D. 1998 Evolutionary Biology (3rd edition). Sinauer Associates, Inc. Mass.
Graur, D. & W-H Li. 1999. Fundamentals of Molecular Evolution. Sinauer Associates, Inc. Mass.
Hurst, L. D., Atlan, A. & Bengtsson, B. O. 1996. Genetic conflicts. *Quarterly Review of Biology*, 71, 317-364.
http://www.ncbi.nlm.nih.gov
http://genome.ucsc.edu

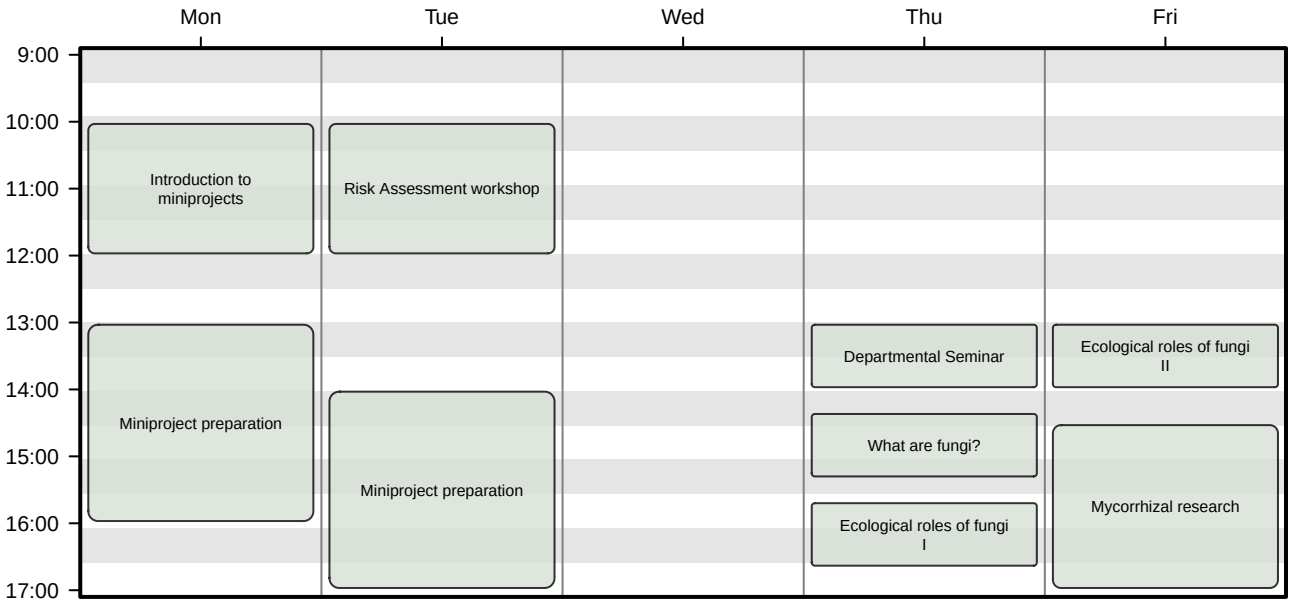
2.2.10 Fungal Biology and Miniproject Introduction

Week: 10 (*Monday 8th December — Friday 12th December*)

Convenor: Martin Bidartondo and David Orme

Fungi are the dominant recyclers, pathogens, and symbionts in terrestrial ecosystems. Their metabolic products are everywhere, from beer, wine, bread, cheese and soft drinks to unfortunate immuno-suppressed patients. We will survey fungal diversity in the broadest sense and then focus on some of the pre-eminent ecological roles of fungi.

Timetable:



Monday 8th December	
09:00 — 10:00	*Microbial Ecology Grant Proposal hand-in deadline* (Coursework) By 09:00
10:00 — 12:00	*Introduction to miniprojects* (Discussion, Fisher, David Orme)
13:00 — 16:00	*Miniproject preparation* (Work time)
Tuesday 9th December	
10:00 — 12:00	*Risk Assessment workshop* (Workshop, Fisher, Stefan Hoyle)
14:00 — 17:00	*Miniproject preparation* (Work time)
Thursday 11th December	
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:20 — 15:20	*What are fungi?* (Lecture, Fisher, Martin Bidartondo) Big picture evolutionary diversity from slime moulds to basidiomycetes. Diversity of life cycles from ancient asexuals to five spore stages.
15:40 — 16:40	*Ecological roles of fungi I* (Lecture, Fisher, Martin Bidartondo) 1) recyclers of wood, 2) symbionts of plant shoots (endophytes), and 3) symbionts of plant roots (arbuscular mycorrhizas and ectomycorrhizas).
Friday 12th December	
13:00 — 14:00	*Ecological roles of fungi II* (Lecture, Fisher, Martin Bidartondo) Further aspects of fungal ecology.
14:30 — 17:00	*Mycorrhizal research* (Discussion, Fisher, Martin Bidartondo) Student-led presentation and discussion of landmark mycorrhizal biology research articles (available from Blackboard and to be notified later).

Reading:

Moore D, et al. (2011) 21st Century Guidebook to Fungi, Cambridge UP. (or any other recent Fungal Biology, Mycology or Botany textbook).
Smith SE, Read DJ (2008) Mycorrhizal Symbiosis, 3rd ed., Academic Press.

2.2.11 Demography and management

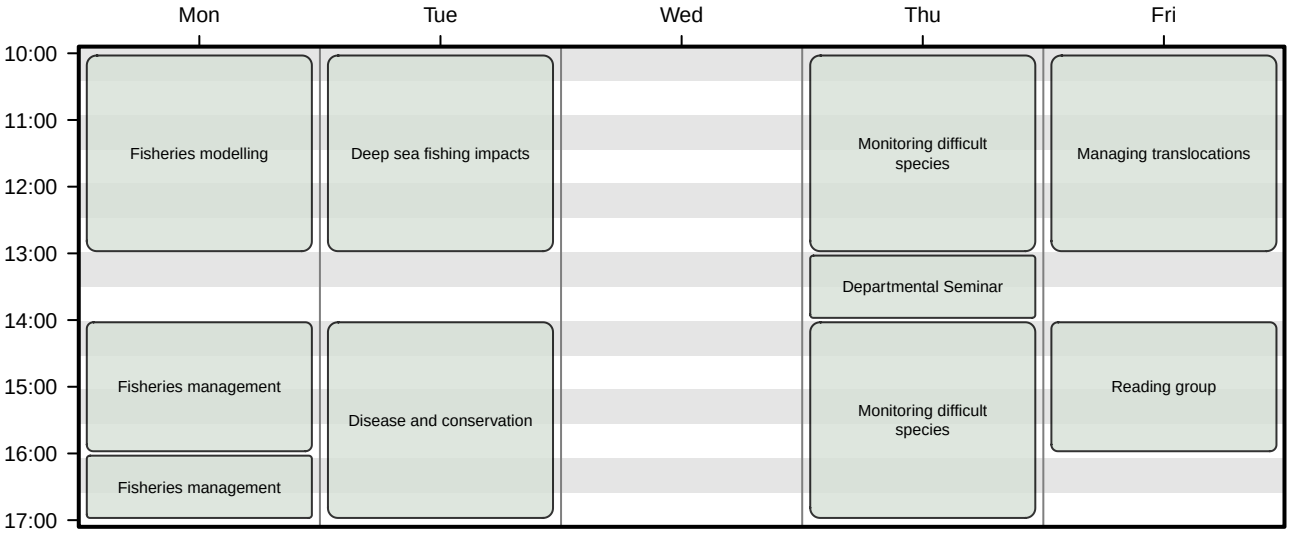
Week: 15 (*Monday 12th January — Friday 16th January*)

Convenor: Marcus Rowcliffe

In this module, we will look at the impact of the demography of species on their managment.

This module is taught jointly with the Conservation Science MSc.

Timetable:



Thursday 8th January	
10:00 — 13:00	*January essay exam* (Exams, Fisher) Essay questions on weeks 1-8 and winter seminars
Monday 12th January	
10:00 — 13:00	*Fisheries modelling* (Lecture, Haldane, Pia Orr)
14:00 — 16:00	*Fisheries management* (Lecture, Haldane, Pia Orr)
16:00 — 17:00	*Fisheries management* (Computer Practical, Hamilton Computer Room, Pia Orr)
Tuesday 13th January	
10:00 — 13:00	*Deep sea fishing impacts* (Lecture, Fisher, Kirsty Kemp)
14:00 — 17:00	*Disease and conservation* (Lecture, Fisher, Tony Sainsbury)
Thursday 15th January	
10:00 — 13:00	*Monitoring difficult species* (Lecture, Fisher, Richard Young) In this session we will examine the role new technology and analytical techniques can play in improving our ability to monitor the state of wildlife populations, focussing on a number of case studies to highlight particularly important developments. During a group exercise, students will apply this information to design monitoring programmes for a number of example species.
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Monitoring difficult species* (Lecture, Fisher, Richard Young)
Friday 16th January	

10:00 — 13:00	*Managing translocations* (Lecture, Fisher, John Ewen) Conservation translocations include reintroduction, reinforcement, ecological replacement and assisted colonization. Eventually they may also be the ultimate goal of de-extinction! Moving and releasing organisms for conservation is a complex undertaking and involves risk. Further, we are often working with problems we know little about (high uncertainty) and have relatively limited ability to learn (rare species and small sample sizes). To navigate this complexity it is useful to think of planning and implementation as a decision problem, or series of decisions, and use multi-attribute decision analytic tools to help make the best choices. Further it is helpful to design translocations as experiments to test hypotheses about the system, targeting uncertainty that may influence future decisions. I will introduce these ideas in this session.
14:00 — 16:00	*Reading group* (Discussion, Fisher, Marcus Rowcliffe)

Reading:

Thompson, W.L. (2004). Sampling Rare or Elusive Species: Concepts, Designs, and Techniques for Estimating Population Parameters. Island Press, Washington D.C.
IUCN (2013) Guidelines for Reintroductions and Other Conservation Translocations. Gland, Switzerland. Available for download on the IUCN SSC/RSG website.
Ewen, J.G. & Armstrong, D.P. (2007) Strategic monitoring of reintroductions in ecological restoration programmes. *Ecoscience* 14: 401-409.
Canessa, S., Hunter, D., McFadden, M., Marantelli, G. & McCarthy, M.A. (2014) Optimal release strategies for cost-effective reintroductions. *Journal of Applied Ecology* 51: 1107-1115.
Converse, S.J., Moore, C.T., Folk, M.J. & Runge, M.C. (2013) A matter of tradeoffs: reintroduction as a multiple objective decision. *The Journal of Wildlife Management* 77: 1145-1156.
Seddon, P.J., Moehrenschlager, A. & Ewen, J.G. (2014) Reintroducing resurrected species: selecting deextinction candidates. *Trends in Ecology and Evolution* 29: 140-147.
Ewen, J.G., et al (2012) Reintroduction Biology: Integrating Science and Management. Wiley-Blackwell.

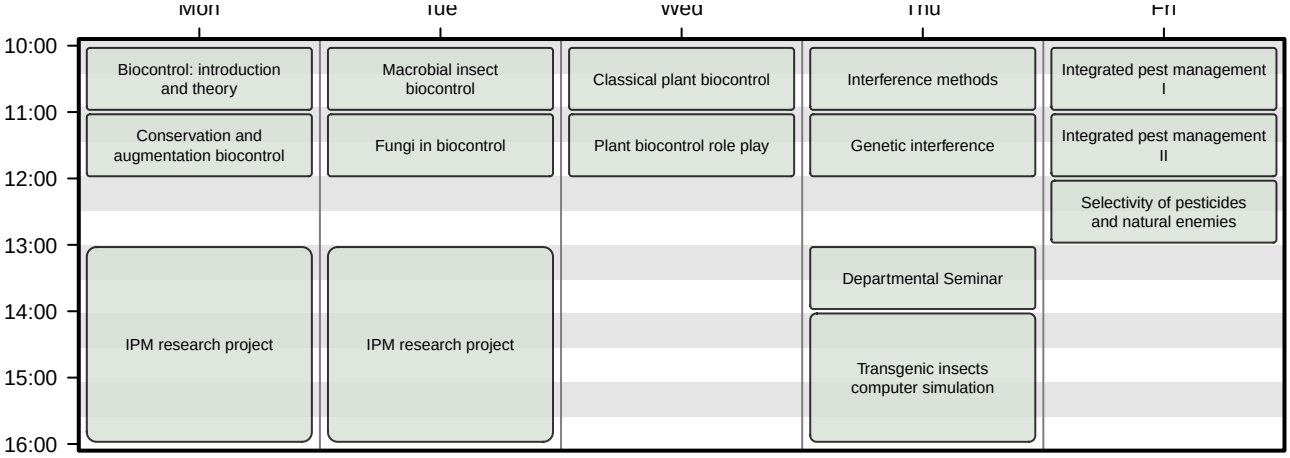
2.2.12 Biological control and integrated pest management

Week: 16 (*Monday 19th January — Friday 23rd January*)

Convenor: Ben Raymond

One of the most economically important applications of ecological knowledge is in the management of pests and invasive species. This is particularly true of management solutions that do not use synthetic pesticides. In this course you will be introduced to the theory and practice of biological control, namely the use of natural enemies or pathogens to suppress pest populations. The course will also cover alternative technologies such as Sterile Insect Technique and transgenic insects as well as integrated pest management, in which diverse control methods are combined optimally based on a knowledge of population biology and target environment.

Timetable:



Monday 19th January

10:00 — 11:00 *Biocontrol: introduction and theory* (Lecture, Fisher, Ben Raymond)
11:00 — 12:00 *Conservation and augmentation biocontrol* (Lecture, Fisher, Ben Raymond)
13:00 — 16:00 *IPM research project* (Work time, Ben Raymond)

Tuesday 20th January

10:00 — 11:00 *Macrobial insect biocontrol* (Lecture, Fisher, Sean Murphy / Bryony Taylor (CABI))
11:00 — 12:00 *Fungi in biocontrol* (Lecture, Fisher, Sean Murphy / Bryony Taylor (CABI))
13:00 — 16:00 *IPM research project* (Workshop, Ben Raymond)

Wednesday 21st January

10:00 — 11:00 *Classical plant biocontrol* (Lecture, Fisher, Richard Shaw)
11:00 — 12:00 *Plant biocontrol role play* (Workshop, Fisher, Richard Shaw)

Thursday 22nd January

10:00 — 11:00 *Interference methods* (Lecture, Fisher, Ben Raymond)
11:00 — 12:00 *Genetic interference* (Lecture, Fisher, Nina Alphey)
13:00 — 14:00 *Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 16:00 *Transgenic insects computer simulation* (Computer Practical, Fisher, Nina Alphey)

Friday 23rd January

10:00 — 11:00 *Integrated pest management I* (Lecture, Fisher, Denis Wright)
11:00 — 12:00 *Integrated pest management II* (Lecture, Fisher, Denis Wright)
12:00 — 13:00 *Selectivity of pesticides and natural enemies* (Lecture, Fisher, Denis Wright)

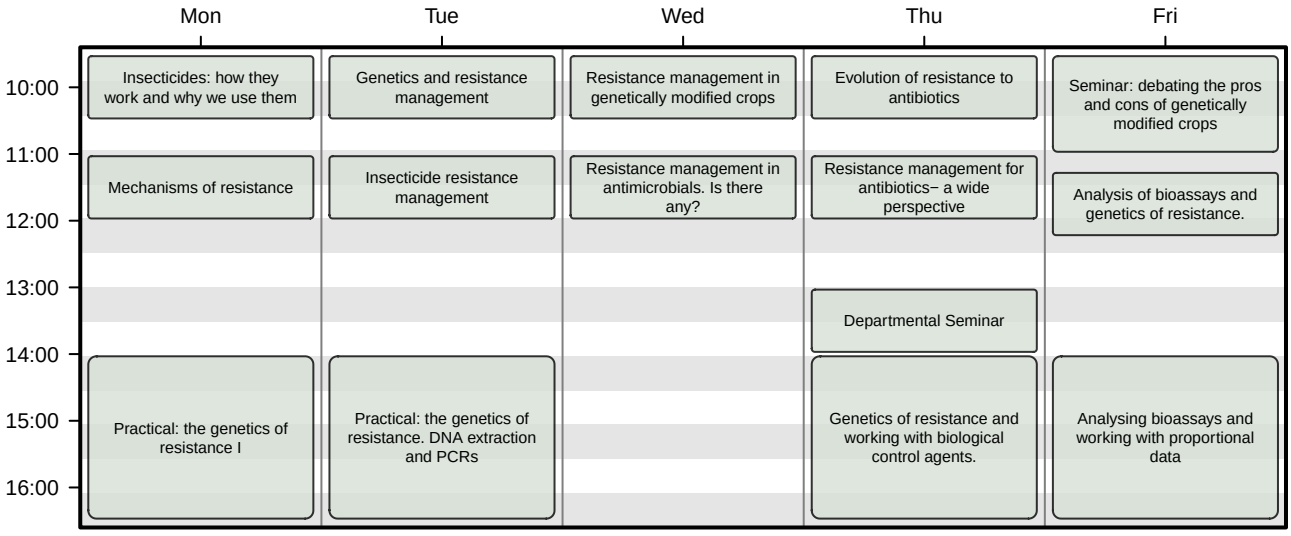
2.2.13 Applied evolution and sustainable pest management

Week: 17 (*Monday 26th January — Friday 30th January*)

Convenor: Ben Raymond

Evolutionary biology is not purely an academic discipline. The sustainable production of food and our ongoing treatment of infectious disease are affected by evolution, primarily the evolution of resistance to pesticides and antibiotics. The enormous selection pressure that we impose on diverse organisms means that managing or mitigating resistance is not a trivial problem. In this course we will explore the theory and practice behind resistance management. We will discuss a range of case studies, from antimicrobials to genetically modified crops. We will compare examples of good practice with areas in which the field is poorly developed. The practicals will be primarily hands-on laboratory based exercises designed to illustrate the genetics of resistance and to provide some experience of working with biological control agents.

Timetable:



Monday 26th January	
09:30 — 10:30	*Insecticides: how they work and why we use them* (Lecture, Fisher, Ben Raymond) An introduction to agronomy, the pro and cons of intensive agriculture. Diverse insecticides and their mode of action.
11:00 — 12:00	*Mechanisms of resistance* (Lecture, Fisher, Ben Raymond) How resistance arises and how often.
14:00 — 16:30	*Practical: the genetics of resistance I* (Lab practical, Hamilton Field Lab, Ben Raymond) This practical will use bioassays to explore the genetics of resistance to the entomopathogen Bacillus thuringiensis and explore issues of cross-resistance between diverse biocontrol agents.
Tuesday 27th January	
09:30 — 10:30	*Genetics and resistance management* (Lecture, Fisher, Ben Raymond) The foundation of resistance management in eukaryotes.
11:00 — 12:00	*Insecticide resistance management* (Lecture, Fisher, Ben Raymond) Based on our knowledge of genetics, how do we minimize the rate of the evolution of resistance.
14:00 — 16:30	*Practical: the genetics of resistance. DNA extraction and PCRs* (Lab practical, Hamilton Field Lab, Ben Raymond) Here we will use rapid non-enzymatic DNA extraction and the PCR to genotype insect lines used in our bioassays
Wednesday 28th January	
09:30 — 10:30	*Resistance management in genetically modified crops* (Lecture, Fisher, Ben Raymond) I will discuss the success of this uniquely prophylatic approach that has been used in crops expressing B. thuringiensis toxins and assess current problems and solutions.
11:00 — 12:00	*Resistance management in antimicrobials. Is there any?* (Lecture, Fisher, Ben Raymond) This lecture will discuss the problems of evolution of resistance to antibiotics, antivirals and antimalarials and current thinking (or lack of it) on the possibilities of managing this problem.
Thursday 29th January	
09:30 — 10:30	*Evolution of resistance to antibiotics* (Lecture, Fisher, Ben Raymond) It's not good news.

11:00 — 12:00	*Resistance management for antibiotics- a wide perspective* (Lecture, Fisher, Ben Raymond) Conventional and unconventional means of addressing this problem. Can public health bodies learn from other examples of resistance management?
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 16:30	*Genetics of resistance and working with biological control agents.* (Lab practical, Hamilton Field Lab, Ben Raymond) In this session we will score the assays set up on Monday and run PCRs on agarose gels
Friday 30th January	
09:30 — 11:00	*Seminar: debating the pros and cons of genetically modified crops* (Discussion, Fisher, Ben Raymond) Group session - debating the pro and cons of genetically modified crops. A consideration of the possible positive and negative consequences of GM crops, including issues of resistance management.
11:15 — 12:15	*Analysis of bioassays and genetics of resistance.* (Lecture, Fisher, Ben Raymond) This session will revise the peculiarities of analyzing proportional data and the theory and background for inferring the genetics of resistance from bioassay data.
14:00 — 16:30	*Analysing bioassays and working with proportional data* (Computer Practical, Hamilton Computer Room, Ben Raymond) We will analyze the results of the practicals conducted this week.

Reading:

Read et al (2011) The evolution of drug resistance and the curious orthodoxy of aggressive chemotherapy. *PNAS*. 108, 10871-10877 *(An interesting and potentially radical approach to managing the evolution of resistance to antimicrobials)*
Carrière, Y., Crowder, D. W. & Tabashnik, B. E. 2010 Evolutionary ecology of insect adaptation to Bt crops. *Evolutionary Applications* 3, 561-573.
Lipsitch, M. 2001 The rise and fall of antimicrobial resistance. *Trends in Microbiology* 9, 438-444
Raymond, B., et al. 2007 Exploiting pathogens and their impact on fitness costs to manage the evolution of resistance to *Bacillus thuringiensis*. *Journal of Applied Ecology* 44, 768-780
Richman, D. D. 2006 Antiviral drug resistance. *Antiviral Research* 71, 117-121

2.2.14 Phylogenetics and Evolution in Deep Time

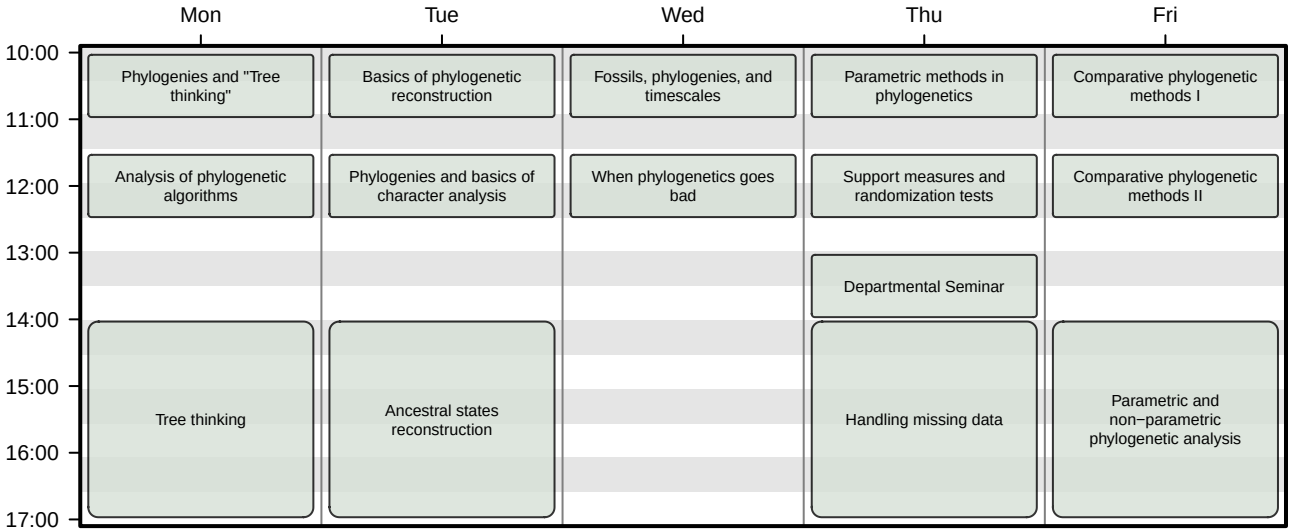
Week: 18 (*Monday 2nd February — Friday 6th February*)

Convenor: Martin Brazeau

Phylogenies are the primary means by which we discover the history of life on earth and understand how modern biodiversity was assembled over evolutionary timescales. Even the fossil record is mute without phylogenetic interpretation of fossils. The aim of this module is to provide a practical background in phylogenetics using morphological and molecular data. This will focus initially on fundamentals of phylogenetics and tree reconstruction and explore topics ranging from using fossils in phylogeny, the effects of missing data, and how phylogenetic trees are applied to study evolutionary patterns and processes.

Learning outcomes:
1) Understanding of basic phylogenetic techniques and concepts 2) Ability to generate and interpret phylogenetic data 3) Understanding of the limitations of phylogenetic data based on sources and methods 4) Introduction to methods of applying phylogenetics to evolutionary probelms

Timetable:



Monday 2nd February	
10:00 — 11:00	*Phylogenies and "Tree thinking"* (Lecture, Fisher, Martin Brazeau)
11:30 — 12:30	*Analysis of phylogenetic algorithms* (Lecture, Fisher, Martin Brazeau)
14:00 — 17:00	*Tree thinking* (Computer Practical, Fisher, Martin Brazeau)
Tuesday 3rd February	
10:00 — 11:00	*Basics of phylogenetic reconstruction* (Lecture, Fisher, Martin Brazeau)
11:30 — 12:30	*Phylogenies and basics of character analysis* (Lecture, Fisher, Martin Brazeau)
14:00 — 17:00	*Ancestral states reconstruction* (Computer Practical, Fisher, Martin Brazeau)
Wednesday 4th February	
10:00 — 11:00	*Fossils, phylogenies, and timescales* (Lecture, Fisher, Martin Brazeau)
11:30 — 12:30	*When phylogenetics goes bad* (Lecture, Fisher, Martin Brazeau) Missing data, character inapplicability, and computational problems in phylogenetics
Thursday 5th February	
10:00 — 11:00	*Parametric methods in phylogenetics* (Lecture, Fisher, Martin Brazeau)
11:30 — 12:30	*Support measures and randomization tests* (Lecture, Fisher, Martin Brazeau)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Handling missing data* (Computer Practical, Fisher, Martin Brazeau)
Friday 6th February	
10:00 — 11:00	*Comparative phylogenetic methods I* (Lecture, Fisher, Martin Brazeau)
11:30 — 12:30	*Comparative phylogenetic methods II* (Lecture, Fisher, Martin Brazeau)
14:00 — 17:00	*Parametric and non-parametric phylogenetic analysis* (Computer Practical, Fisher, Martin Brazeau)

2.2.15 Generalised linear modelling

Week: 19 (*Monday 9th February — Friday 13th February*)

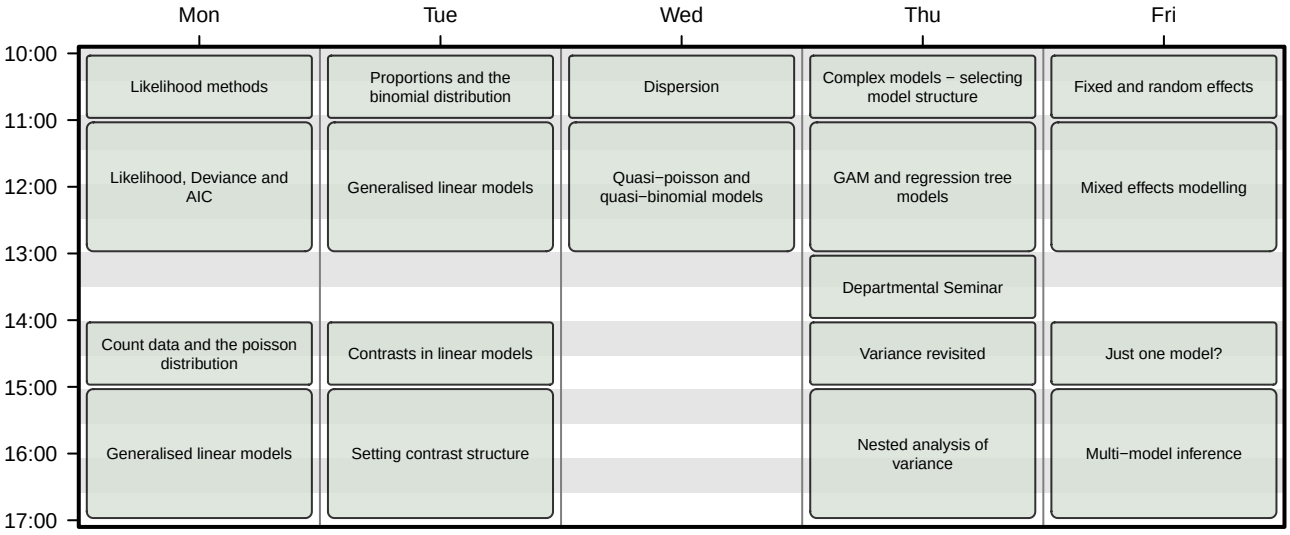
Convenor: David Orme

This module builds on the basic linear models introduced in the previous term to introduce some key concepts that allow linear models to be applied to a wider range of research problems.

This will include using generalised linear models to handle count and binomial data - where residuals are not expected to follow a normal distribution - and the use of structured models to allow for non-

independence in data and to control for known sources of variation in data.

Timetable:



Monday 9th February

10:00 — 11:00 *Likelihood methods* (Lecture, Fisher, David Orme)
11:00 — 13:00 *Likelihood, Deviance and AIC* (Computer Practical, Hamilton Computer Room, David Orme)
14:00 — 15:00 *Count data and the poisson distribution* (Lecture, Fisher, David Orme)
15:00 — 17:00 *Generalised linear models* (Computer Practical, Hamilton Computer Room, David Orme)

Tuesday 10th February

10:00 — 11:00 *Proportions and the binomial distribution* (Lecture, Fisher, David Orme)
11:00 — 13:00 *Generalised linear models* (Computer Practical, Hamilton Computer Room, David Orme)
14:00 — 15:00 *Contrasts in linear models* (Lecture, Fisher, David Orme)
15:00 — 17:00 *Setting contrast structure* (Computer Practical, Hamilton Computer Room, David Orme)

Wednesday 11th February

10:00 — 11:00 *Dispersion* (Lecture, Fisher, David Orme)
11:00 — 13:00 *Quasi-poisson and quasi-binomial models* (Computer Practical, Hamilton Computer Room, David Orme)

Thursday 12th February

10:00 — 11:00 *Complex models - selecting model structure* (Lecture, Fisher, David Orme)
11:00 — 13:00 *GAM and regression tree models* (Computer Practical, Hamilton Computer Room, David Orme)
13:00 — 14:00 *Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 15:00 *Variance revisited* (Lecture, Fisher, David Orme)
15:00 — 17:00 *Nested analysis of variance* (Computer Practical, Hamilton Computer Room, David Orme)

Friday 13th February

10:00 — 11:00 *Fixed and random effects* (Lecture, Fisher, David Orme)
11:00 — 13:00 *Mixed effects modelling* (Computer Practical, Hamilton Computer Room, David Orme)
14:00 — 15:00 *Just one model?* (Lecture, Fisher, David Orme)

15:00 — 17:00 *Multi-model inference* (Computer Practical, Hamilton Computer Room, David Orme)

Reading:

Books you may like to consider are:
Venables, WN & Ripley, BD (2002) Modern Applied Statistics with S (4th Ed). Springer
Pinheiro, J & Bates, DM (2001) Mixed Effects Models in S and S-PLUS. Springer
Sokal & Rohlf (1995) Biometry (3rd Ed). W H Freeman & Co.
Aitkin et al. (2009) Statistical Modelling in R. OUP, Oxford.

2.2.16 Further topics in statistics

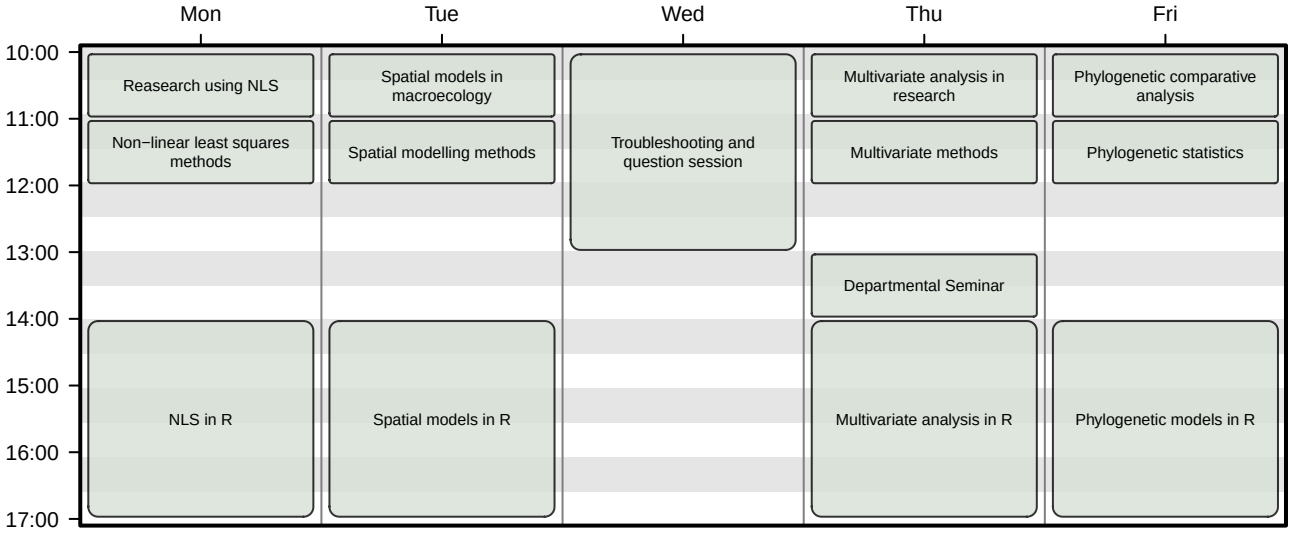
Week: 20 (*Monday 16th February — Friday 20th February*)

Convenor: David Orme

This module will present a series of single day workshops by members of staff on the use of the particular statistical techniques used in their research. The week aims to build familiarity with more complex statistics and with using R and to introduce a wider range of statistical methods that may be of use in projects and in later research.

Each day will introduce the research need for the methods, describe how the method is applied and then use research data to learn the use of the method in practice.

Timetable:



Monday 16th February
10:00 — 11:00 *Reasearch using NLS* (Lecture, Fisher, Samraat Pawar) Fitting curved models to data
11:00 — 12:00 *Non-linear least squares methods* (Lecture, Fisher, Samraat Pawar) Fitting curved models to data
14:00 — 17:00 *NLS in R* (Computer Practical, Hamilton Computer Room, Samraat Pawar)

Tuesday 17th February
10:00 — 11:00 *Spatial models in macroecology* (Lecture, Fisher, David Orme)
11:00 — 12:00 *Spatial modelling methods* (Lecture, Fisher, David Orme)
14:00 — 17:00 *Spatial models in R* (Computer Practical, Hamilton Computer Room, David Orme)

Wednesday 18th February

10:00 — 13:00 *Troubleshooting and question session* (Workshop, Fisher, David Orme)

Thursday 19th February

10:00 — 11:00 *Multivariate analysis in research* (Lecture, Fisher, Greet De Coster)
11:00 — 12:00 *Multivariate methods* (Lecture, Fisher, Greet De Coster)
13:00 — 14:00 *Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00 *Multivariate analysis in R* (Computer Practical, Hamilton Computer Room, Greet De Coster)

Friday 20th February

10:00 — 11:00 *Phylogenetic comparative analysis* (Lecture, Fisher, David Orme)
11:00 — 12:00 *Phylogenetic statistics* (Lecture, Fisher, David Orme)
14:00 — 17:00 *Phylogenetic models in R* (Computer Practical, Hamilton Computer Room, David Orme)

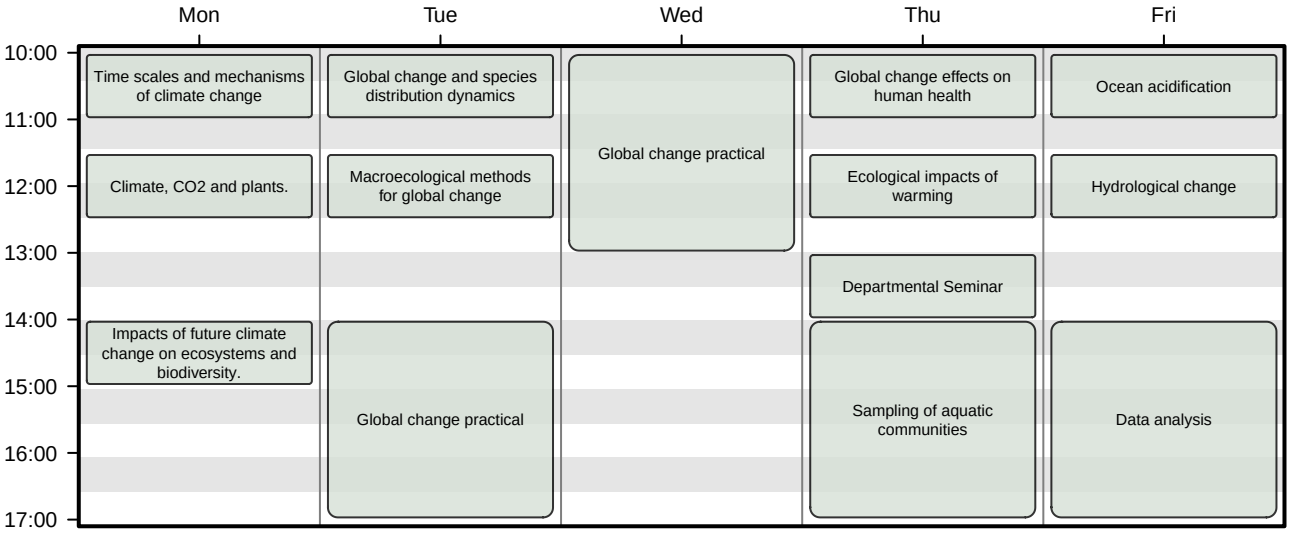
2.2.17 Ecology and global change

Week: 21 (*Monday 23rd February — Friday 27th February*)

Convenor: Colin Prentice, Miguel Araújo and Guy Woodward

Global change covers the ongoing impact on natural systems from a range of anthropogenic activities. Here, we will review the mechanisms be which climate change influences natural systems. The module will then go on to explore research and methods for examining change at the macroecological scale as well as the evidence for climate impacts at smaller, community levels.

Timetable:



Monday 23rd February

10:00 — 11:00 *Time scales and mechanisms of climate change* (Lecture, Fisher, Colin Prentice) Time scales and mechanisms of climate change, from the deep past to the uncertain future. This lecture will provide a general overview of the history of Earth's climate and the different mechanisms in play at different time scales, including rapid climate changes linked to the ice ages, the nature of recent climate change and the evidence for the anthropogenic contribution to recent climate change. It will include an overview of the global carbon cycle.

11:30 — 12:30	*Climate, CO2 and plants.* (Lecture, Fisher, Colin Prentice) This lecture will introduce the various mechanisms that control the distribution and abundance of plants and the function of ecosystems, including physiological effects of CO2 concentration, and the implications for CO2 uptake and release by the terrestrial biosphere.
14:00 — 15:00	*Impacts of future climate change on ecosystems and biodiversity.* (Lecture, Fisher, Colin Prentice) This lecture will deal with the many uncertainties surrounding future scenarios of climate change, the similarities and differences between past and projected future climate changes, and the evidence for different types of response to climate change at the species level.
Tuesday 24th February	
10:00 — 11:00	*Global change and species distribution dynamics* (Lecture, Fisher, Miguel Araújo)
11:30 — 12:30	*Macroecological methods for global change* (Lecture, Fisher, Miguel Araújo)
14:00 — 17:00	*Global change practical* (Computer Practical, Hamilton Computer Room, Babak Naimi)
Wednesday 25th February	
10:00 — 13:00	*Global change practical* (Computer Practical, Hamilton Computer Room, Babak Naimi)
Thursday 26th February	
10:00 — 11:00	*Global change effects on human health* (Lecture, Fisher, Sarah Whitmee)
11:30 — 12:30	*Ecological impacts of warming* (Lecture, Fisher, Dan Perkins)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Sampling of aquatic communities* (Field practical, Hamilton Field Lab, Joe Huddart, Clare Gray)
Friday 27th February	
10:00 — 11:00	*Ocean acidification* (Lecture, Fisher, Becca?)
11:30 — 12:30	*Hydrological change* (Lecture, Fisher, Guy Woodward)
14:00 — 17:00	*Data analysis* (Computer Practical, Hamilton Computer Room, Joe Huddart, Clare Gray)

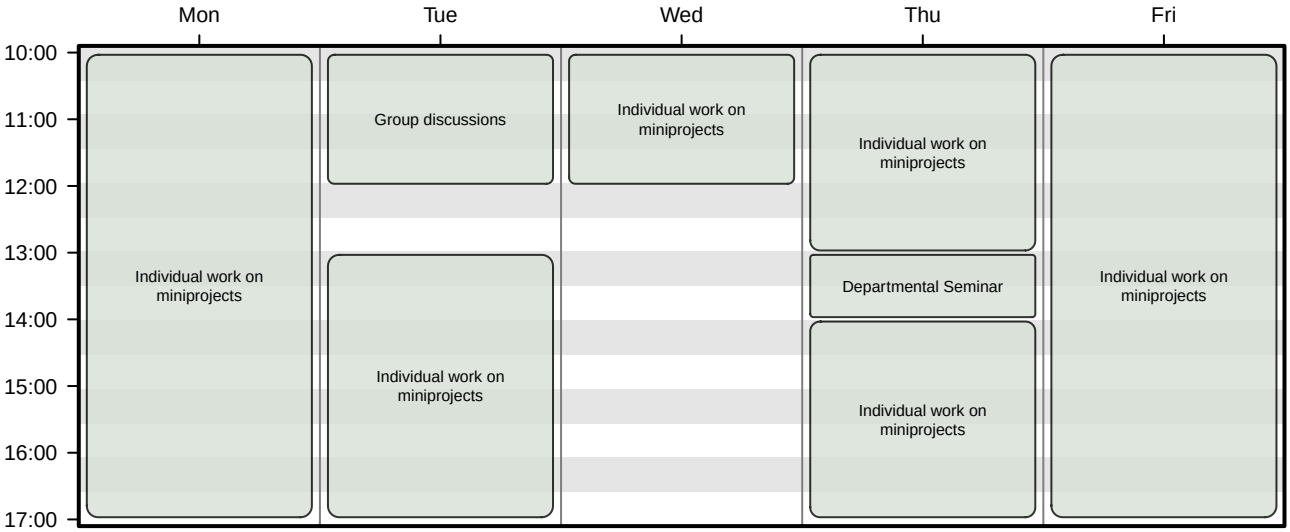
2.2.18 Miniprojects

Week: 22 (*Monday 2nd March — Friday 6th March*)

Convenor: David Orme

The miniprojects provide an opportunity to practice independent research skills before the start of the MSc research project. These two weeks provide time to work on your projects and scheduled support for project development and guidance on analysis and writing.

Timetable:



Monday 2nd March	
10:00 — 17:00	*Individual work on miniprojects* (Work time)
Tuesday 3rd March	
10:00 — 12:00	*Group discussions* (Workshop, Fisher, David Orme) Troubleshooting analyses
13:00 — 17:00	*Individual work on miniprojects* (Work time)
Wednesday 4th March	
10:00 — 12:00	*Individual work on miniprojects* (Work time)
Thursday 5th March	
10:00 — 13:00	*Individual work on miniprojects* (Work time)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Individual work on miniprojects* (Work time)
Friday 6th March	
10:00 — 17:00	*Individual work on miniprojects* (Work time) Demonstrators will be on hand to answer questions if required

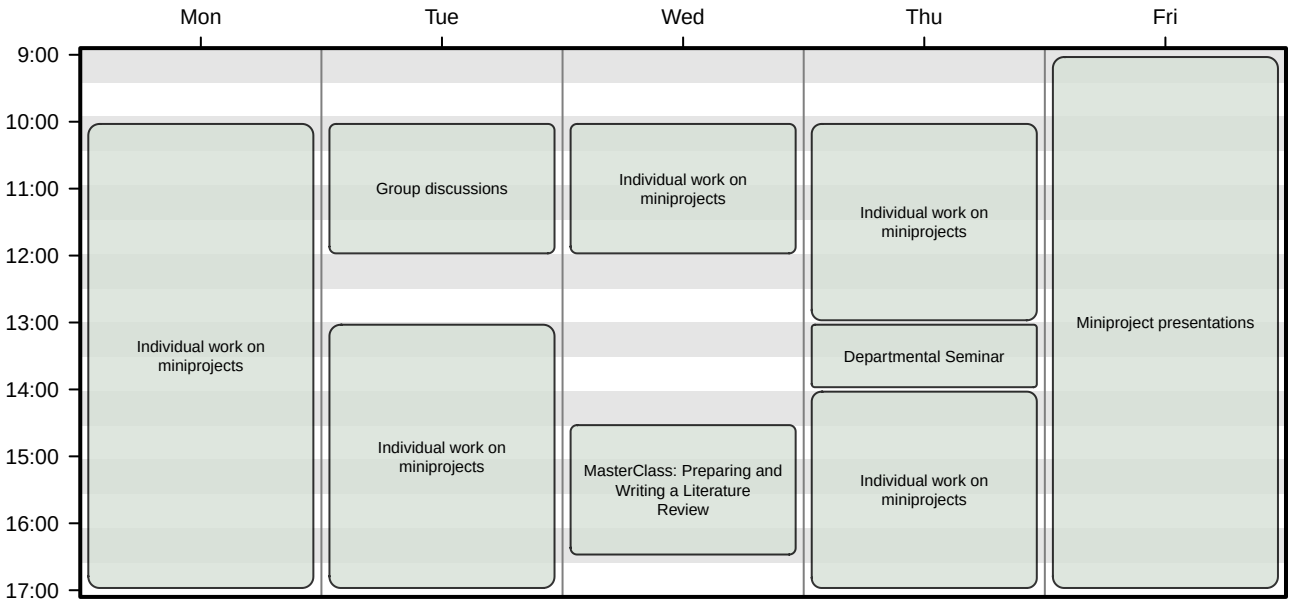
2.2.19 Miniprojects continued

Week: 23 (*Monday 9th March — Friday 13th March*)

Convenor: David Orme

See previous week

Timetable:



Monday 9th March	
10:00 — 17:00	*Individual work on miniprojects* (Work time)
Tuesday 10th March	
10:00 — 12:00	*Group discussions* (Workshop, Fisher, David Orme) Troubleshooting analyses
13:00 — 17:00	*Individual work on miniprojects* (Work time)
Wednesday 11th March	
10:00 — 12:00	*Individual work on miniprojects* (Work time)
14:30 — 16:30	*MasterClass: Preparing and Writing a Literature Review* (Workshop, Graduate School) This workshop is provided by the Graduate School and you may need to reserve a place on the course through their website.
Thursday 12th March	
10:00 — 13:00	*Individual work on miniprojects* (Work time)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Individual work on miniprojects* (Work time)
Friday 13th March	
09:00 — 17:00	*Miniproject presentations* (Coursework, Fisher, David Orme) Each student will have 10 minutes to introduce their question, explain their methods, show what their findings were, discuss the limitations and interpretation, and briefly state what they would do next if they had more time. *These presentations are assessed as a piece of coursework*.

2.2.20 Behavioural ecology

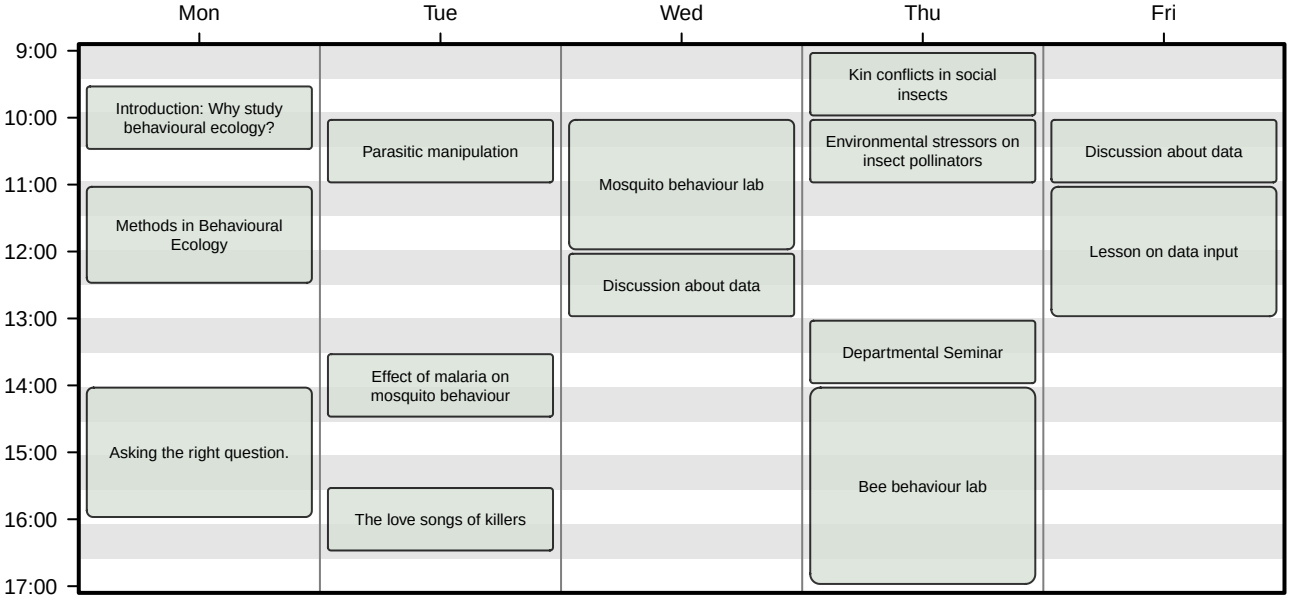
Week: 24 (*Monday 16th March — Friday 20th March*)

Convenor: Lauren Cator and Rich Gill

Whether it is the dance of the honeybee, the dawn chorus of birds or the march of the penguins, the behaviour of animals has long captured the human imagination and the attention of ecologists. In this module we will explore the methods used by behavioural ecologist to test hypotheses about the evolutionary and ecological forces that shape behaviour. The course will touch upon a variety of behavioural

ecology topics and provide many case studies to show how experiments can be designed effectively and how behaviour can be appropriately quantified to test the question(s) posed.

Timetable:



Monday 16th March	
09:00 — 10:00	*Miniproject hand-in deadline* (Coursework) By 09:00
09:30 — 10:30	*Introduction: Why study behavioural ecology?* (Lecture, Fisher, Lauren Cator)
11:00 — 12:30	*Methods in Behavioural Ecology* (Lecture, Fisher, Lauren Cator)
14:00 — 16:00	*Asking the right question.* (Field Practical, Hamilton Field Lab, Lauren Cator) We are going to be spending time outside (bring rain gear!)
Tuesday 17th March	
10:00 — 11:00	*Parasitic manipulation* (Lecture, Fisher, Lauren Cator)
13:30 — 14:30	*Effect of malaria on mosquito behaviour* (Lecture, Fisher, Lauren Cator)
15:30 — 16:30	*The love songs of killers* (Lecture, Fisher, Lauren Cator)
Wednesday 18th March	
10:00 — 12:00	*Mosquito behaviour lab* (Lab Practical, Hamilton Field Lab, Lauren Cator)
12:00 — 13:00	*Discussion about data* (Discussion, Fisher, Lauren Cator)
Thursday 19th March	
09:00 — 10:00	*Kin conflicts in social insects* (Lecture, Fisher, Lauren Cator)
10:00 — 11:00	*Environmental stressors on insect pollinators* (Lecture, Fisher, Lauren Cator)
13:00 — 14:00	*Departmental Seminar* (Lecture, Haldane, Visiting staff)
14:00 — 17:00	*Bee behaviour lab* (Lab Practical, Hamilton Field Lab, Rich Gill)
Friday 20th March	
10:00 — 11:00	*Discussion about data* (Lecture, Fisher, Rich Gill)
11:00 — 13:00	*Lesson on data input* (Lecture, Fisher, Rich Gill)

Reading:

Reading:
Martin and Bateson. 2007. Measuring Behaviour: An Introductory Guide . Cambridge University Press.

Papers for Discussion:
Thomas et al. (2005) Parasitic manipulation: where are we and where should we go? *Behavioural Pro-*

cesses. 68. 185-199.

2.3 Research projects

Research project topics are generally part of ongoing active research within the Department and across a range of academic partners. As a result, research project topics are often developed either around the start of the programme in September for MRes winter projects or during the first two terms for MRes and MSc summer projects.

We maintain an online spreadsheet of available projects and new project proposals will be added to this throughout the year. The details of available projects are available from these two links:

Webpage http://goo.gl/GWtgy6

Tab delimited text file http://goo.gl/awH7Vf

This spreadsheet will provide broad details of research projects but the precise topics of projects will be finalised in discussion between the student and potential supervisors. Project descriptions will appear throughout the year but we aim to provide the majority of project topics by the following deadlines:

MRes Winter project topic deadline 12th October 2014

MSc and MRes Summer project topic deadline 15th March 2015

The following sections on potential supervisors and broad research areas are intended to guide you in thinking of the topics you might be interested in and in which staff to approach. All projects must have a Silwood supervisor or co-supervisor, but can also be based at external organisations with additional external supervision. Previous external organisation include Royal Botanic Gardens, Kew, English Nature, the Game Conservancy and so on. A list of previous project topics is provided on Blackboard.

Where new supervisors add projects after printing the handbook, details of their research interests may be downloaded from these links:

Webpage http://goo.gl/okOvZS

Tab delimited text file http://goo.gl/aVGHs4

2.3.1 Internal supervisor research areas

Miguel Araújo

I have a wide range of interests in biogeography, conservation biology, global change biology, and macroecology. My research is driven by three unifying questions: 1) how did past climate changes affect the distribution of biodiversity? 2) how might current and future environmental changes affect biodiversity? 3) how can biodiversity be conserved given current and future challenges? To address these questions, I integrate large climatic and species distributions databases with descriptions of behavioural and physiological traits of species, molecular phylogenies, and the fossil record. Most research involves statistical analyses of ecological data, including data mining, bioclimatic modelling and mathematical simulations, but large-scale experiments, including mesocosm experiments, are now being devised for testing ecological and evolutionary models and theory.

Cristina Banks-Leite

Understanding bird responses to deforestation in South America and the consequences of species extinction to the loss of functional diversity. An example projects could use data previously collected on birds from the Atlantic Forest and Amazon as well as collate a database on species morphological and behavioural traits. The aim is to address questions such as; which response traits are related to species sensitivity to deforestation; does species extinction lead to loss of functional diversity; and are response and effect traits correlated.

Tim Barraclough

Evolutionary biology and species diversity; speciation in asexual rotifers; evolution in bacterial communities including human gut bacteria.

Morgan Beeby

I am interested in how the molecular machinery of the cell assembles, functions, and evolves. To tackle this problem I use electron cryo-tomography, a technique that enables us to visualize this machinery inside living cells – to resolutions capable of discerning individual proteins. The technique involves flash-freezing the specimen then imaging it over a range of angles in an electron microscope. The resulting images can then be used to determine the 3-D structure of the specimen in a manner directly analogous to CT or CAT scans. Bacteria are the biological subjects of my studies: the (relative) simplicity of bacteria make them ideal subjects for study of basis biological principles, yet with considerable practical application in, for example, antibiotic development or sustainable re-utilization. My primary focus at the moment is the bacterial flagellar motor, a nanoscale motor that spins a helical filament to act as a propeller for the bacterium. I am particularly interested in a number of curious variants of the motor that we recently identified, as these differences promise to shed light upon some basic principles of assembly, function, and evolution.

Tom Bell

Projects are available on microbial ecology and evolution. Projects will involve testing ecological and evolutionary theory using microbial communities as a model system. Projects could typically include laboratory and field work. General areas of interest include:

- Biodiversity and ecosystem functioning. Biodiversity is thought to be an important determinant of ecosystem-level processes (e.g. decomposition). Projects in this area will look at the ecological mechanisms that contribute to biodiversity-ecosystem functioning relationships, and at how biodiversity affects functioning over evolutionary timescales.
- Microbial biogeography. Spatial patterns of microbial community composition and diversity remain understudied. Projects might include, for example, manipulating rates of colonisation to understand how community assembly affects community membership.
- Trophic interactions. Projects will involve examining the role of protists in structuring bacterial community composition. Several hundred protist and bacterial isolates are available to construct food webs and to examine the relative roles of resource competition and predators in determining bacterial community dynamics.

Martin Bidartondo (Royal Botanic Gardens, Kew)

I supervise projects on the ecology and evolution of plant-fungal interactions that may be field, glasshouse, laboratory and/or computer-based. Current interests include the evolutionary ecology of the fungal symbioses of ancient plant lineages and the ecological drivers of mycorrhizal diversity in trees.

Austin Burt

I supervise computer-based projects on population genetic data analysis and population genetic modelling.

Magda Charalambous

I supervise projects on insect mating behaviour and sexual selection. In the past I have had projects on Drosophila, crickets and bulb mites (to look at alternate male mating behaviours). We have video/sound recording facilities available and have used jWatcher software both as an event recorder and to produce transitional probabilities for ethograms. I am happy to discuss any project with a behavioural angle and also to act as internal supervisor for behavioural projects undertaken away from Silwood.

Mick Crawley

Example projects include:

- Plant species richness and coexistence in annuals. Temporal variation is one of the mechanisms postulated as fostering coexistence in species-rich systems. This project uses a 12-year old, ongoing field experiment at Pound Hill in Silwood Park, where replicated plots have been cultivated in October, March or May each year. They now have highly distinctive floras and seed banks. The project addresses questions about the species specific details of coexistence under the 3 disturbance regimes, with particular attention to population densities, plant size, seed production and mortality.
- Invertebrate herbivores and plant biodiversity in grasslands. The Nash's Field experiment has run since 1992. It involves 12 different nutrient treatments in grassland (combinations of nitrogen, phosphorus, potassium and magnesium), crossed with two liming treatments (limed and unlimed) and 3 plant competition treatments (control, minus-grass and minus herb in the first 3 years). The project concerns the relative importance of vertebrate herbivores (rabbits and deer) and invertebrate herbivores (insects and molluscs) in determining species diversity and plant community composition. The project has direct relevance to conservation of species-rich grassland.
- Experimental studies of the regeneration niche in plants.This project is about seed-limitation; if you add more seeds, will you get more plants? The work centres on the long-term field experiment in Oak Mead in which 60 species were sown in 1996 under a range of conditions relaxing the intensity of plant competition and herbivory. When seed addition leads to the establishment of more plants, then evidently regeneration niches of that species existed at the time of sowing. The project involves the collection of new field data on the invasion of grassland from these sown epicenters (e.g. Linaria repens) and analysis of existing data sets (e.g. local extinction of species that established from seed under conditions of low competition, or low herbivory).
- Impacts of red deer (Cervus elaphus) grazing on plant communities on Rum. The issue of deer numbers in Scotland is well known, and the impact of grazing on plant communities has been studied for many years on the island of Rum. There is an opportunity to join the team on Rum to gather new data on plant-herbivore dynamics.

Rob Ewers

I work on spatial patterns of forest and the biodiversity contained within those forests. Work involves investigating and trying to predict patterns of forest cover from local through to global scales, sampling of taxa within selected landscapes, and manipulative field experiments. Most of the work uses invertebrates as a model system, and is focused at the Stability of Altered Forest Ecosystems (SAFE) Project in Malaysian Borneo.

Jason Hodgson

My research focuses on human and primate evolutionary genetics. I use genomic SNP and next-gen sequence data, as well as bioinformatic approaches to test evolutionary hypotheses.

I am particularly interested in the way that local adaptation and gene flow have contributed to the distribution of genetic variation. As a globally distributed species, human populations have experienced myriad selective environments and consequently local adaptation has driven population differentiation between regions. Recent migrations associated with the development of agriculture and efficient transportation have spread locally adapted genetic variants across the landscape. I use recently admixed populations to understand the fate of locally adapted alleles when they are introduced to new environments through migration. I am currently working with the people of

Madagascar, but also work on populations from the Horn of Africa, Middle East, and Oceania.

I am also interested in all aspects of primate evolution. I am particularly interested in integrating molecular phylogenetics with the fossil record to produce a more nuanced understanding of primate evolution.

E.J. Millner-Gulland

I supervise projects on a broad range of topics in conservation and development, human-wildlife interactions, hunting and wildlife trade, human behaviour and evaluation of conservation successes and failures. Each year I offer one or more specific projects on my saiga antelope research, in collaboration with the Saiga Conservation Alliance. For more detail on my research interests see www.iccs.org.uk.

David Orme

My research has centred on trying to explain distributions of biodiversity across phylogenies and in space: why are some groups of organisms or places unusually species rich and species poor. I have also looked at differences in diversity between taxonomic groups and possible implications for conservation. More recently, I have been exploring how dispersal and evolutionary history give rise to patterns of species distribution and how these variables may be used in predicting responses to climate change. I have supervised projects on both the phylogenetic and spatial distribution of diversity on small and large scales and also have in interest in marine systems.

Samraat Pawar

My group studies dynamics of biological systems across levels of organization, from individuals to communities. We use a combination of mathematical and computational modeling and analyses of massive ecological data sets. We work across organisms and ecosystems, and are particularly interested in the structural and functional differences and similarities between terrestrial and aquatic communities. You can find further details and information on specific projects we are currently involved in by visiting http://imperial.ac.uk/people/s.pawar.

Iain Colin Prentice

Understanding and modelling fundamental carbon, water and nutrient cycling processes at the plant and ecosystems levels. Global carbon cycle modelling and climate feedbacks. Assessment of the impacts of global climate and CO2 changes for natural ecosystems, water resources and crops.

Andy Purvis

Integrative biodiversity science: interests in conservation biology (modelling and projecting responses of species, populations, functional diversity and ecosystem services to human impacts, in both natural and managed systems), macroevolution (primarily in planktonic foraminifera), and phylogenetic comparative biology (especially models of trait evolution)

James Rosindell

My main areas of research interest are biodiversity theory, island biogeography, ecological neutral theory and scientific data visualisation. I offer a range of projects on these topics all of which would involve the opportunity to develop programming skills and apply scientific computing to ecology and evolution. The island biogeography projects would involve modeling the richness and abundance of endemic and native species on island archipelagos. Ecological neutral theory is a controversial area of biodiversity theory that uses very simple models; projects here would involve introducing extra realism to these models and fitting them to tropical moist forest tree datasets. Students working on the data visualisation project would be contributing to a wider initiative to provide software to visualize the tree of life and information on each species within it. The software will be for use by scientists and as a tool for public outreach and education on the subjects of ecology and evolution.

Vincent Savolainen

Work in my lab combines field ecology, molecular phylogenetics, population genetics, and genomic approaches to help explain the origin of biodiversity and, where possible, find solutions for its preservation in a rapidly changing world. Most projects will have a wet lab component (genetics and genomics), possibly a field component too (UK, Australia, Africa).

Blake Suttle

I am a community ecologist focused on climate change impacts on the natural world and human well-bring. My research considers how changing ecological interactions may broker climate change impacts on ecosystems, public health, and food security. I am interested in experimental projects, literature syntheses and meta-analyses, and modelling approaches to exploring these questions.

Mike Tristem

I am interested in projects in the following areas:

- Endogenous retrovirus insertional polymorphisms in humans. The published human genome sequence contains over 98,000 endogenous retroviruses (ERVs) but all are defective, containing lethal mutations or major deletions. Only one family of HERVs (human ERVs), termed HERV-K(HML2), has been active since the divergence of humans and chimpanzees approximately 6 mya. The family contains many members that are human-specific as well as several that are insertionally polymorphic, an integrated element being present in some human individuals but not in others. Possible projects will identify additional insertional polymorphisms via PCR screening of different human individuals. Any polymorphisms will be useful as (i) population markers, (ii) in assessing prehistoric human migration patterns and (iii) investigating the present day activity of HERVs.
- Domestication of human endogenous retroviruses. Some ERVs have become domesticated or co-opted and hence fulfil a function of benefit to the host (e.g. preventing infection by other viruses). Identifying such elements has been very slow to date. However, with the recent sequencing of the human and chimpanzee genomes the process will be much faster and can be accomplished using bioinformatics. Thus possible projects will compare orthologous (in the same location) ERVs in the two genomes. Selection since the divergence of the two hosts will be examined with any evidence of purifying selection indicating domestication of the elements being examined.

2.3.2 External organization research areas

The examples below give outlines of project areas from some recent partners. More projects with external partners are likely to arise during the course. In the first instance, please contact the course directors about possible projects with external organizations.

Centre for Ecology and Hydrology, Wallingford

Research areas for projects are based around ecological modelling of UK systems, often with practical or policy implications. Previous topic areas include the following:

- Are extinction risks of plant species larger on the edge of distributions than in the centre? Based on Atlas data of the UK and the Netherlands we will look at spatial patterns in range decay of over a wide range of species over the last 50 years. Next to geographical patterns, a range of alternative environmental indicators for correlated extinction will need to be explored. Such information could feed into priorities to set in conservation of declining species.
- Dynamics of butterfly range expansion. Understanding landscape effects on colonisation and extinction can help us to facilitate species movements under changing climates. This project

will investigate how landscape structure affects the colonisation of new sites at leading range margins. In addition, local extinctions will be related to landscape characteristics.

- Managing habitats for butterfly populations. Butterfly populations are highly sensitive to land management and understanding the long term effects management regimes can aid conservation. This project will investigate how nature reserves managed in different ways affect butterfly population dynamics. For example, does a heterogeneous management regime lead to more robust and stable populations?
- Floral homogeneity in the UK: the effects of non-native plants and urbanisation. Biotic homogenisation is regarded as a potential cause of biodiversity loss and is strongly linked with the arrival and dominance of non-native plants and animals and urbanisation. Using an extensive dataset on plant distributions at a tetrad scale collected at 2 time periods by the Botanical Society of the British Isles (BSBI) throughout the UK we will calculate similarity indices and look at spatial and temporal trends in similarity for native and non-native plants to investigate whether there is any signs of homogeneity in the British flora and what the mechanisms behind this are addressing questions such as: Are habitats that are more similar associated with higher numbers of alien species? Are urban habitats more similar than habitats in the wider countryside? Have plant communities become more homogeneous over time in the UK?

UNEP-World Conservation Monitoring Centre (UNEP-WCMC)

A wide range of projects addressing global/regional biodiversity and ecosystem services issues, including: international agreements synergies, conservation priority setting, international trade and regional economies, drylands and livelihood support, wildlife trade and social networks, access and benefit sharing, protected area targets and social values, monitoring deforestation and degradation, and more.

Somerset Wildlife Trust

Broad research interests cover the interaction of land use methods and biodiversity on lowland wetlands. A variety of projects are possible from looking at restoration of biodiversity on restored peat extraction sites through to examining the effects of drainage and re-wetting on peat soil integrity and micro-arthropod diversity. Many projects are available concerning the conservation of nationally rare invertebrate species.

2.3.3 Thesis format and submission

Note that different courses at Silwood have different guidelines and past projects are not all written in the style required here.

The write-up should be in the style of a scientific paper from a journal that it might be appropriate for submission to. You should avoid using the format of general science journals such as Science, Nature or PNAS: research from the course has been published in high-impact general science journals but the unusual layout and compact style make it harder to write your report well.

By journal style, we mean the structure and how information is presented – it should have an abstract (maybe keywords), introduction, methods, results, and discussion (possibly conclusions). You *do not* need to make it look like a pdf of published paper and shouldn't try - it takes ages to get it right!

If the results of your project are publishable, this approach will save much time and will provide valuable experience in paper writing. You may provide appendices if necessary (for example outlining methods in detail).

Always aim to be clear and concise. The size of the thesis will vary according to the student and project,

but aim to make it as short as necessary to describe the work done and to discuss it in a general context. However, *do not* omit relevant data and information such as experimental procedures. An EEC Masters thesis should not exceed 6,000 words in length (excluding figures, tables, references and appendices). However, a common mistake is to assume that the reader knows the project as well as you do and to leave out clear descriptions of the motivation and structure of your research.

There are a few ways in which your thesis is likely to differ from a typical scientific paper:

1. You should make sure that you clearly state your aims/hypotheses/questions towards the end of your introduction.
2. You should take care to explain everything adequately so that the examiners can see clear evidence of understanding of all the concepts and methods – this might entail providing more detail or background in the introduction and methods than in a typical paper. However, some of this detail can be put in an appendix. For example, a molecular study might state in the Methods section of the main text that you extracted DNA according to a phenol/chloroform extraction protocol according to a particular reference. In the appendix, you should then describe the steps of your lab protocol in sufficient detail that other people could reproduce this procedure by following your description.
3. You should make it clear what you did versus what you were provided with. For example, did you collect the data that you analyzed or were they provided to you by someone else?
4. You should make sure to discuss limitations of your study and what future work you would do to address those limitations or any other questions raised by your work. In your project, most likely you will run out of time to complete everything you want to do. In most papers, the research would not be so time limited so limitations can be addressed by further work.

Blackboard has a folder with more advice on scientific writing, and papers from Conservation Biology, Proceedings of the Royal Society B, Molecular Ecology, and Journal of Animal Ecology, which we recommend as well-written example papers.

The final thesis must follow these preparation guidelines:

Cover Page

The cover page *must* bear the project title, your name and the month and year of submission. In addition, the following text must appear at the bottom of the cover page:

> A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science/Research at Imperial College London
>
> Formatted in the journal style of XXX.
> Submitted for the MRes/MSc in Ecology, Evolution and Conservation

Obviously, insert your choice of journal and choose the appropriate degree course.

Declaration

The first page inside the cover must provide a brief declaration of the contributions made by you and by others to your project. Key points to address are:

- Was the data provided to you or did you collect or assemble it?
- Were you responsible for data processing or cleaning, if required?
- Were any mathematical models developed by you or by your supervisor?
- What role, if any, did your supervisor play in developing the analyses presented?

Layout

The main body of the text should use 1.5 line spacing and page numbering should be used. The

thesis margins should be at least 2 cm and the main text font size should not be smaller than 11 point.

2.3.4 Project submission

The main deadline is for the *submission of the electronic version* of your project. This must be submitted as a single file in either PDF or Word format. If you have multiple sections, combine them all into a single document before submitting. If you find that Word explodes if you try and combine your files into a final document, then it may be easier to export each Word file to a pdf, check them and then merge them into a single PDF. Some methods to do that are here: http://www.wikihow.com/Merge-PDF-Files.

You must use the following naming convention for your report file:

Surname_FirstName_Course_Year.docx

So for example:

Orme_David_EEC_2014.docx
Raymond_Ben_EEC_2014.pdf

Follow the instructions above *carefully* for the project structure to make sure you include everything including the declarations. There is an Word version of the official cover sheet on the Blackboard site in the Assessment Materials folder if you want to include an official cover on your electronic copy. Go to the assignments button on the course Blackboard site, select the appropriate project hand in ('Summer' or 'Winter') , use 'Add Attachments' to upload your file and then click 'Submit'. (We cannot access the file unless you click submit!) If you have any problems uploading, try moving to a different computer or browser.

You will also need to *produce three bound copies* of your thesis. One of these is for the external examiners, which is later put in the Library, and one for use by internals markers and your supervisor. The final copy is your own, which you *must* take with you to your internal and external viva examination. There are spiral binding machines in the Computer Room along with pre-printed official card cover sheets, plastic front protectors and white card back covers.

You must *submit two of the bound copies* to Amanda in the two days following the electronic deadline - this is just to avoid a rush on the binding machines at the same time as you are all typing your last words! Obviously the printed version *must* be identical to the printed version, including the pagination and any cover sheet.

2.3.5 Thesis content guidelines

The following guidelines on content include top tips from Andy Purvis, author of over 100 scientific papers and referee of many more.

Introduction

A good introduction should leave the reader with a clear idea of the problem to be tackled and looking forward to the more detailed sections to follow. It should include a section on the general way the problem has been approached. An essential concluding part of the introduction is to clearly define the aims of the research project and any hypotheses tested.


Andy's top tips

- *What is this paper about? (i.e., the broad area, big picture) Why is that interesting?*
- *Given it's so interesting, why don't we know the answer?*
- *So, what is this about, more specifically? What are hypothesised to be the important things?* Build from the most general and fundamental hypotheses to the most refined or tenuous ones.
- *How, roughly and briefly, will you go about testing these hypotheses?* Why are you using this system? What approach will you use?
- State clearly what your hypotheses are. These are not usually stated explicitly in a paper.

Methods

This should contain details of any methods used extensively during the project, layout of field experiments, methods of statistical analyses etc. You can use subheadings for different procedures or tests. If field work is done, a general description of the study area may be included here. Extra methodological details can be placed in appendices. The golden rule is that the reader should be able to repeat what you did, should they so wish. The other rule – more important for your project than in a paper – is that you describe in enough detail to show you've understood what you did.

You should feel free to use subheadings in your methods and results to help organise different parts of your project. If so, keep the same order of the different parts of the project in all of your sections: the methods for testing each hypothesis and the results of those tests are described in the same order as the hypotheses are described in the introduction.


Andy's top tips

- What is the overall design of the study?
- What are the variables and how do they relate to the hypotheses?
- How did you get the data?
- What are the characteristics of the data set / experiment – how many observations, how many replicates etc.
- General procedures, if any, that are true in all of the analyses (e.g., transformation of data, model checking, how models were compared)
- How did you test the hypotheses, in the logical order outlined in the introduction (i.e., from the general to the specific)? Make sure you show that your tests are appropriate.

Results

Describe your results in a logical order: this may not necessarily be the order in which you did the experiments. Briefly summarise the main results at the end of each main experiment or sequence of associated experiments. Do not duplicate results – put a table or a graph but not both unless the two methods of presentation demonstrate different points of importance. You must refer appropriately to figures or tables in the text and remember to emphasise and perhaps quote significant results.


Andy's top tips

- What were the results of your hypothesis tests, in the order you describe them in the Methods?

Discussion

This should attempt to tie together the results, what they indicate in a broader context, the extent to which the original aims have been satisfied and what future work is suggested. Return to and

address the ideas raised in the introduction.

Andy's top tips

- *What's the main thing we know now that we didn't know before?*
- What's the chain of logic and results that means we know it?
- *How does this affect our – and other scientists' – view of the world? What are the implications?*
- What are the implications of the intermediate steps in the chain towards the main thing?
- What are the caveats that apply to this study? (Leave out caveats that apply to all studies.) What might be done about them? (Very important in a project write-up – What would you do differently if you were doing the project again or had more time?)
- What future work could build more broadly on what we've found?
- A nice wrap-up, emphasising how this study in this system is of interest to people who work on other things, or other systems.

Abstract

Now, and only now, write the abstract, making sure it includes the key point from each of Andy's top tips above that are *emphasized*. Don't rush the abstract – it is your first opportunity to tell a reader about the research and a clear, concise abstract sets them up to understand your work!

References

It is *highly* recommended that you use bibliographic software (e.g. Endnote, Refworks, Papers, Mendeley) to manage and format your citations. Make sure all cited references appear in this list at the end of the thesis using the standard style from your chosen journal.

Appendices

Large sets of data (e.g. census results, 'raw' experimental results) should go in an Appendix if these are of value, e.g. indicating an interesting range of variation. All summary tables or graphs and outline results of analysis should be put in the text. Any useful parts of the study not directly relevant to the main theme may also be put in an Appendix (e.g. taxonomic descriptions and drawings in an otherwise ecological study).

Computer Programs

If the program has been published, cite the reference, include it in the reference list and provide a brief outline of the methods it uses. If you are using a program or code generated for the project then a more complete description is needed in the main text. You should provide the code used in an appendix and consider providing a flow chart and usage notes to help interpretation. You should take care to define all the input variables used in the program.

Figures

You should prepare figures to the same standard required for publication. All journals provide advice on preparing figures for publication, so do look at the advice to authors pages for your chosen journal. All figures must be numbered and have a caption that is sufficiently detailed to explain the main features of the content by itself. All figures *must* be referred to in the main text of the thesis. Put the figures in appropriate points in the text, close to the text that refers to them. In particular:

- The resolution of your figures is crucial. For plots, try to use vector image formats and not bitmapped formats like JPG and TIFF. When using Word 2007 on PC, figures in Windows Metafile format are the most reliable vector format. For Word 2011 on Mac, figures in PDF format should give a good result. If you do have to use bitmaps, make sure they are at a high resolution (300 dpi or more) – this can be particularly important if you need to present line drawings or photographs of specimens or equipment.

- Plots are all about the data, so reduce margins and maximise the space in the figure for showing the data.
- Create the figure at the right size – when it is included in your thesis are all the axis labels and text going to be clearly legible.
- Avoid 'chartjunk' (google Edward Tufte!) – and avoid superfluous lines, legends and titles along with 3D effects (Figure 1).

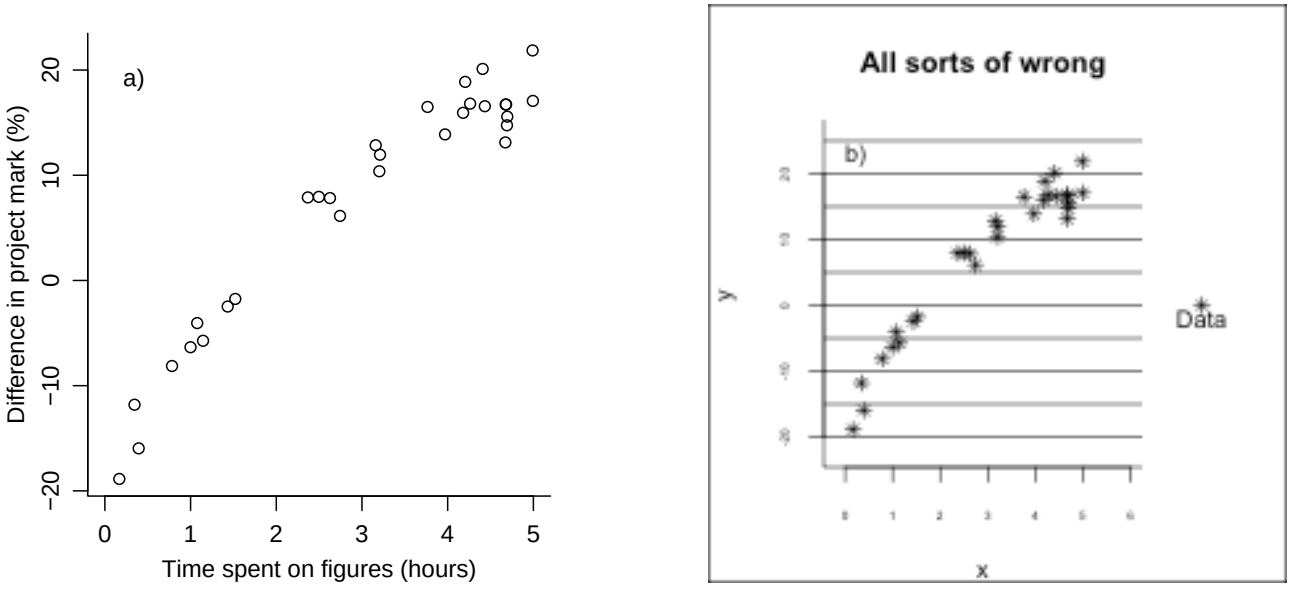


Figure 1: The relationship between effort on figure preparation and final project mark: a) considerable effort expended and b) insufficient effort expended.

Tables

Each table should be numbered, have a full descriptive caption and again *must* be referred to in the main text. Column headings should state units of measurement. Avoid large, complicated tables in the main thesis and if you have a large body of numerical data put it in an appendix.

2.4 Course aims, objectives and learning outcomes

2.4.1 Aims

The *aims* of the EEC Masters programme are:

- To develop understanding of the fundamental principles underlying research in ecology, evolution and conservation.
- To provide broad training in practical and analytical research skills relating to ecology, evolution and conservation.
- To show how these principles and skills can be applied to solve real problems facing the biosphere.
- To prepare students for a career in conservation or applied biology.
- To prepare for PhD studies and make an informed choice of research topic.

The principle difference between the MSc and MRes options is in the balance between the two first aims. MSc students spend more time developing a broad understanding of the direction and principles of current research areas. In contrasts, MRes students will spend more time in developing independent research skills within the same field.

2.4.2 Objectives

The course *objectives* are that, on completion of the course, the student should have:

- An understanding of basic and applied aspects of theoretical ecology as it applies to population dynamics, community dynamics, succession, habitat structure and ecosystem function
- An understanding of modern evolutionary theory and the methods of phylogenetic reconstruction and genomics as applied to ecological and evolutionary problems.
- An understanding of the broad issues concerning conservation of the biosphere and biodiversity, from local to global scales.
- An ability to choose an appropriate ecological or evolutionary model to answer a particular question for conservation
- An ability to generate, analyse and interpret typical ecological and evolutionary data and databases met in conservation work
- A broad appreciation of the scientific opportunities within the Division of Biology, Imperial as a whole, collaborating research and conservation institutions and globally in the area of ecology, evolution and conservation.
- A range of transferable skills including: communication skills (oral and written); project design, implementation and evaluation, team project coordination; computing, statistics and mathematical modelling; specific research skills.

2.4.3 Learning outcomes

This section sets out the key knowledge, skills and abilities that graduates of the MSc and MRes programmes should expect to have acquired. The MSc and MRes programmes differ to some degree in the main teaching and learning methods and strategies by which these outcomes will be achieved and assessed and these differences are noted below.

1 Knowledge and Understanding Students will acquire knowledge and understanding of:

a) basic and applied ecology as it relates to population and community dynamics and ecosystem function;

b) ecological models and their application to predict dynamics and guide population management;

c) evolutionary theory as it relates to the origins and dynamics of diversity;

d) methods of evolutionary analysis, especially molecular approaches for population studies and phylogenetics;

e) research techniques, including information retrieval, experimental design and statistics, modelling, sampling, molecular biology, laboratory and field safety;

f) detailed knowledge and understanding of the essential facts, concepts, principles and theories relevant to the student's chosen area of specialisation;

g) management and communication skills, including problem definition, project design, decision processes, teamwork, written and oral reports, scientific publications.

MSc programme Acquisition of 1a to 1d is through a combination of lectures, seminars, laboratory work, computer-based work, coursework and visits (October to March). Acquisition of 1e is through a combination of lectures, laboratory work, computer-based work and visits, through an individual mini-project with group feedback, and through the full-time, individual, supervised research project (April to September). Acquisition of 1f is through a combination of lectures, laboratory work, coursework and visits and through individual study guided by the supervisors of research projects. Acquisition of 1g is through a combination of lectures, laboratory exercises, coursework, small group projects linked to workshops with group and individual presentations. Throughout the course, students are encouraged to undertake independent reading both to supplement and consolidate what is being taught/learnt and to broaden their individual knowledge and understanding of the subject.

Assessment of the knowledge base is through a combination of unseen written exams (1a-1f), assessed coursework and practical write-ups (1a -1g), students' individual project write-ups (1e-1g), and an oral exam by the external examiner (1a-1g).

MRes programme Acquisition of 1a to 1d is through a combination of lectures, seminars, laboratory work, computer-based work, coursework and visits (October to November). Acquisition of 1e is through a combination of lectures, laboratory work, computer-based work and visits, and through the two full-time, individual, supervised research projects (November to September). Acquisition of 1f is through a combination of lectures, laboratory work, coursework and visits and through individual study guided by the supervisors of research projects. Acquisition of 1g is through a combination of lectures, laboratory exercises, coursework, small group projects linked to workshops with group and individual presentations. Throughout students are encouraged to undertake independent reading both to supplement and consolidate what is being taught/learnt and to broaden their individual knowledge and understanding of the subject.

Assessment of the knowledge base is through the written reports and viva voce after the completion of each of the two projects (in March and September). Marks for each project will be equally weighted, each contributing 50% of the final mark (each = 45 ECTS credits). At the end of the year the student will be examined by viva voce by two visiting examiners.

2 Intellectual Skills Students will be able to:

a) analyse and solve ecological, evolutionary and practical conservation problems using an integrated multidisciplinary approach;

b) integrate and evaluate information;

c) formulate and test hypotheses using appropriate experimental design and statistical analysis of data;

d) plan, conduct and write-up a programme of original research.

MSc programme Intellectual skills are developed through the teaching and learning methods outlined above and through the learning programme set out in this handbook. Information sifting and sorting, analysis and problem solving skills are promoted through the use of resource packs in the group project exercises and workshops embedded in the core course. Experimental design and statistical skills are developed in lectures, computer-based practical work in the

core course, the coursework mini-projects and group sessions, and subsequently in the individual research projects. Individual, formative and summative feedback is given to students on all work produced including oral presentations. Assessment is through coursework and the individual research projects.

MRes programme Intellectual skills are developed through the teaching and learning methods outlined above and through the learning programme set out in this handbook. Information sifting and sorting, analysis and problem solving skills are promoted through the use of resource packs in the group project exercises and workshops embedded in the core course. Experimental design and statistical skills are developed in lectures and computer-based practical work in the core course and subsequently in the individual research projects. Individual, formative and summative feedback is given to students on all work produced including oral presentations. Assessment is through the individual research projects.

3 Practical Skills Students will be able to:

a) plan and execute safely a series of experiments;

b) use laboratory and field–based methods to generate data;

c) devise theoretical models for given problem and implement them in computer simulations;

d) analyse experimental results and determine their strength and validity;

e) prepare technical reports;

f) give technical presentations;

g) use the scientific literature effectively;

h) use computational tools and packages.

Practical skills are developed through the teaching and learning programme outlined in this handbook. Practical experimental skills (3a to 3d) are developed through laboratory, computer-based and project work. Skills 3e and 3f are taught and developed through feedback on reports written and presentations made as part of coursework assignments. Skill 3g is developed through lectures, coursework reports and essays, group project exercises and the individual supervised research project. Skill 3h is taught and developed through coursework exercises and project work. Practical skills are assessed through practical write-ups, coursework reports and the research project dissertations.

4 Transferable Skills Students will be able to:

a) communicate effectively through oral presentations, written reports and scientific publications;

b) apply statistical and modelling skills;

c) management skills: decision making, problem definition, project design and evaluation, risk management, teamwork and coordination

d) integrate and evaluate information from a variety of sources;

e) transfer techniques and solutions from one discipline to another;

f) use Information and Communications Technology;

g) manage resources and time;

h) learn independently with open-mindedness and critical enquiry;

i) learn effectively for the purpose of continuing professional development.

Transferable skills are developed through the teaching and learning programme outlined in this handbook. Skill 4a is taught through coursework and developed through feedback on reports, essays and oral presentations. Skill 4b is taught through lectures and practical work and developed, as appropriate, during individual research project. Skills 4c to 4e are developed through project work in lab teams. Skill 4f is developed through computer-based exercises, projects and other coursework activities and individual learning. Skill 4g is developed throughout the course within a framework of staged coursework deadlines and the research project planning. Although not explicitly taught, skills 4h and 4i are encouraged and developed throughout the course, which is structured and delivered in such a way as to promote this.

Skill 4a is assessed through coursework, workshop presentations, and the oral examination. Skill 4b is assessed through coursework and project work. Skills 4c to 4e are assessed in workshops. The other skills are not assessed formally.

2.5 Staff-Student Committee

In addition to the PG-SOLE online feedback, we will hold three Staff-Student Committee meetings each year, with meetings at the end of the first and second term and after the hand-in deadline for the summer research projects. We will ask for representatives from both the MSc and MRes programs at the start of the course. The dates of the meetings will be fixed at the start of the course and displayed on the course electronic timetable.

Minutes from Staff-Student Committee meetings will be circulated within two weeks along with responses, where required, to any points raised.

College guidelines on good practice for Staff-Student Committees area available here: http://www3.imperial.ac.uk/registry/proceduresandregulations/qualityassurance/goodpractice

2.6 MSc course regulations

The following notes outline the Department of Biological Science's rules for awarding MSc Degrees (2008 edition – updated September 2011). The University's General Regulations and the College's Special Regulations should be consulted in all cases of doubt.

Course credit requirements

The scheme outlined is that accepted formally by the University and by Imperial College London for the award of *MSc in Ecology, Evolution and Conservation*.

[All modules are compulsory]

Class Boundaries

The final degree mark will be used to classify MSc degrees according to the following notional boundaries:

Distinction	70% or more
Merit	60% or more (less than 70%)
Pass	50% or more (less than 60%)
Fail	below 50%

These boundaries are moderated at the Examiners' Meeting to take account of your performance over the year and any difficulties you may have experienced (such as illness).

Assessment of Performance

Taking the Course

The word 'take' in the context of these regulations means that you have attended the timetabled parts of a course (unless prevented by illness), sat its examination, submitted the coursework specified for it and completed a research project.

Illness or bereavement

A student who is unable to complete his or her exams because of illness or the death of a near relative must either sit the examination at the next normal time or have a special paper set for them. Original documentation, e.g. doctor's letter, should be provided as supporting evidence by the student at the earliest opportunity.

Taught Modules

All modules are assessed by a combination of a written examination and coursework, consisting of assessed essays, reports or practical class write-ups.

Coursework

Receipt of marks for assessed coursework is absolutely dependent upon you delivering the work by the stated deadlines (making due allowance for sickness). Marks for assessed practical class reports can be gained only if you attend and perform the relevant practicals.

Research Projects

Assessment will be by written report and viva voce after the completion the project.

a) The Supervisor will comment on your performance during the project, sending the mark direct to the Examinations Officer. This assessment is worth 20% of the final project mark).

b) Your project report will be marked by two internal examiners: a Marker who is a member of staff familiar with the relevant scientific field and an Assessor who is a member of staff marking many masters projects. Exceptionally, advice may be sought from scientists of equivalent standing from outside the Division;

c) The Marker and Assessor will both mark the thesis (report) and agree a mark (worth 60% of the final project mark).

d) The Supervisor and Marker and Assessor should each add a written justification of their marks to the marking forms to inform the External Examiners.

e) The Marker and Assessor will viva the student and assign a mark based on the student's performance in the viva (worth 20% of the final project mark).

f) In the case of the Marker and Assessor differing in 10% or more in their mark, a third person, usually one of the Course Directors, will also assess the thesis and a thesis mark will be assigned based on agreement among the three markers.

External Vivas

Each candidate will be interviewed on his/her project by the External Examiner, the purpose being to reveal any problems the candidate may have had with the project, and to probe their understanding of the research they undertook. There is no mark attached to the viva with the external examiner, but the examiner will take part in moderation discussions and use the feedback from students in assessing the quality of the course.

Resit Examinations

a) If you should fail the examination you are entitled to resit it the next two times it is offered;

b) if the coursework element failed to reach the threshold 50% mark, whether through inadequacy or lateness of submission, the student will normally be asked to repeat the specific failed course components (i.e. take them again);

c) a candidate who has attended most of a course but fails its coursework element because of ill health or bereavement will normally be allowed to resubmit the relevant coursework by a new deadline;

d) a candidate who has taken a course but fails to sit its exam because of ill health or bereavement will normally be allowed to carry over their coursework mark for that course to when they next take the exam.

(We are currently seeking permission from the Masters' Quality Committee to offer resit examinations in November and December in order to speed up the process of completing the course when resits are required.)

Contribution to Final Degree Marks by Various Course Elements

Element 1

The taught course. This contributes 50% of the final mark. It comprises two components: coursework (four pieces, together 20% of final mark) and written examinations (three exams, together 30% of the final mark).

Element 2

The research project. This contributes 50% of the final mark.

Rules

a) Both elements of the assessment must be passed before a degree of MSc can be recommended.

b) To pass the taught course element, the aggregate marks for both the coursework and the examination components must be above 50%, as well as receiving an aggregate mark for the taught course above 50%;

c) If you fail the taught course, then you would normally resit any failed exam papers the following year. (Note that – when re-sitting exams – the overall weighted exam average will be capped at 50%). If you fail the coursework component of the taught course you will be allowed to resubmit the failed coursework if it is deemed to be appropriate;

d) To pass the project element of the course you must obtain a mark of 50%;

e) If you fail the research project or the coursework component of the taught course then you would normally retake the course the following year.

f) All students must attend a viva by the External Examiner.

g) Project reports normally to be submitted in early September – vivas with the External Examiner are in late September prior to the Examinations Board Meeting.

h) Only when a detailed case has been made and accepted by the Board will candidates be moderated into a different degree class from that associated with their aggregate final mark. In such cases, the Board may be guided by a notional 'Grey Area' (up to and including 2% below the threshold mark) within which the degree class might be moderated.

i) To achieve a Distinction, candidates should normally get 70% overall. Additionally, at least two of the three marks (for the project element, the coursework component of the taught course element, and the exam component of the taught course element) should be at least 70% and none should be less than 60%. To achieve a Merit, candidates should normally get 60% overall, with at least two of the three marks (for the project element, the coursework component of the taught course element, and the exam component of the taught course element) being 60% or more.

j) Course convenors and project supervisors have a responsibility to notify the Examination Officer of exceptional circumstances known to them that might have affected the course mark given to a candidate; likewise personal tutors must record the existence of any medical or personal problems that might have affected performance in examinations or assessed coursework, and notify the MSc Office. All such circumstances must be made known to the Chair prior to the meeting of the Board of Examiners so that a preliminary assessment can be made of their likely effect, and additional information sought where necessary.

2.7 MRes course regulations

The following notes outline the Department of Biological Science's rules for awarding MRes Degrees (2008 edition – updated September 2011). The University's General Regulations and the College's Special Regulations should be consulted in all cases of doubt.

Course credit requirements

The scheme outlined is that accepted formally by the University and by Imperial College London for the award of *MRes in Ecology, Evolution and Conservation Research*. [All modules are compulsory; section 2 lists the required modules]

Class Boundaries

The final degree mark will be used to classify MSc degrees according to the following notional boundaries:

Distinction	70% or more
Merit	60% or more (less than 70%)
Pass	50% or more (less than 60%)
Fail	below 50%

These boundaries are moderated at the Examiners' Meeting to take account of your performance over the year and any difficulties you may have experienced (such as illness).

Assessment of Performance

Taking the Course

The word 'take' in the context of these regulations means that you have attended the timetabled parts of a course (unless prevented by illness), sat its examination, submitted the coursework specified for it and completed a research project.

Illness or bereavement

A student who is unable to complete his or her exams because of illness or the death of a near relative must either sit the examination at the next normal time or have a special paper set for them. Original documentation, e.g. doctor's letter, should be provided as supporting evidence by the student at the earliest opportunity.

Taught Modules

will include:
Plant Community Ecology and Conservation
Speciation and the Evolution of Biodiversity
Macroevolution and micropaleontology
Population Dynamics & Modelling
Aquatic Resource Ecology
Statistical Computing

Research Projects

Assessment will be by written report and viva voce after the completion of each of the two projects in March and September.

a) The Supervisor will complete Form I on your performance during the project, sending the mark direct to the Examinations Officer. This assessment is worth 20% of the final project mark).

b) Your project report will be marked by two internal examiners: a Marker who is a member of staff familiar with the relevant scientific field and an Assessor who is a member of staff

marking many masters projects. Exceptionally, advice may be sought from scientists of equivalent standing from outside the Division;

c) The Marker and Assessor will both mark the thesis (report) and agree a mark (worth 60% of the final project mark).

d) The Supervisor and Marker and Assessor should each add a written justification of their marks to Forms I and II, to inform the External Examiners.

e) The Marker and Assessor will viva the student and assign a mark based on the student's performance in the viva (worth 20% of the final project mark).

f) In the case of the Marker and Assessor differing in 10% or more in their mark, a third person, usually one of the Course Directors, will also assess the thesis and a thesis mark will be assigned based on agreement among the three markers.

External Viva

After the second project in September, you will be given a viva by one of the external examiners. External examiners will be given your project reports shortly after your internal viva. This external viva will contribute to moderation of the marks awarded by the Division's assessors and examiners and determine whether students should be awarded a merit or distinction.

Rules

a) Both elements of the assessment must normally be passed before a degree of MRes can be recommended.

b) If a research project mark is a fail then the student would normally retake the project the following year.

c) All students must attend a viva by the external examiner.

d) Project reports are normally to be submitted in March and September and vivas with the internal and external examiners are in late September prior to the Examinations Board Meeting.

e) Only when a detailed case has been made and accepted by the Board will candidates be moderated into a different degree class from that associated with their aggregate final mark. In such cases, the Board may be guided by a notional 'Grey Area' (up to and including 2% below the threshold mark) within which the degree class might be moderated.

f) To achieve a Distinction, candidates should normally gain 70% overall, and at least 60% for both projects. To achieve a Merit, candidates should normally gain 60% overall. To achieve a pass, candidates should normally gain 50% overall, and at least 50% on both projects.

g) Course convenors and project supervisors have a responsibility to notify the Examination Officer of exceptional circumstances known to them that might have affected the course mark given to a candidate; likewise personal tutors must record the existence of any medical or personal problems which might have affected performance in examinations or assessed coursework, and notify the MSc Office. All such circumstances must be made known to the Chair prior to the meeting of the Board of Examiners so that a preliminary assessment can be made of their likely effect, and additional information sought where necessary.