

# MSc and MRes in Computational Methods in Ecology & Evolution: Introduction

Samraat Pawar & James Rosindell

*Silwood Park*

**Imperial College  
London**

October 6, 2015

# WHY ECOLOGY AND EVOLUTION?

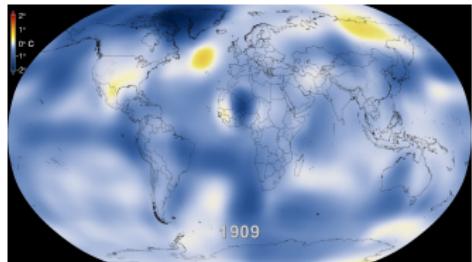


*Big Fish Eat Little Fish*, 1557, Pieter van der Heyden

# BECAUSE WE LIVE IN “INTERESTING” TIMES

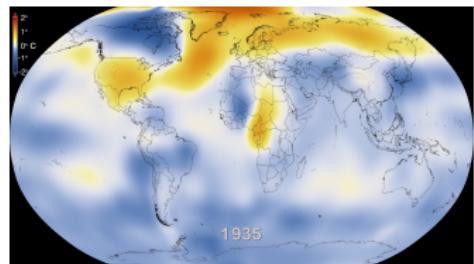
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- Climatic warming and fluctuations



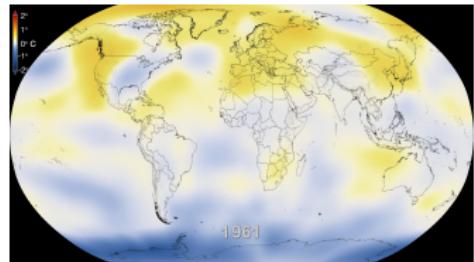
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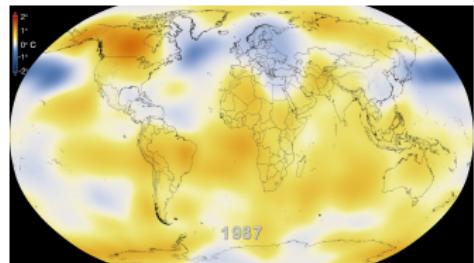
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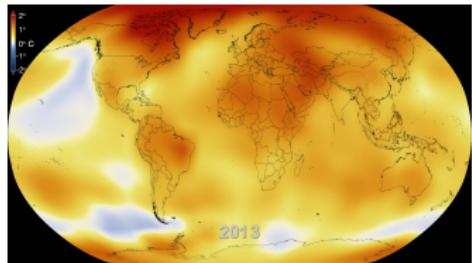
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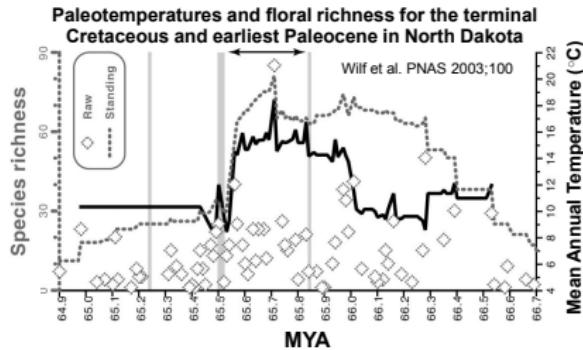
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- Climatic warming and fluctuations
- Species range shifts and invasions
- Overexploitation of ecosystems



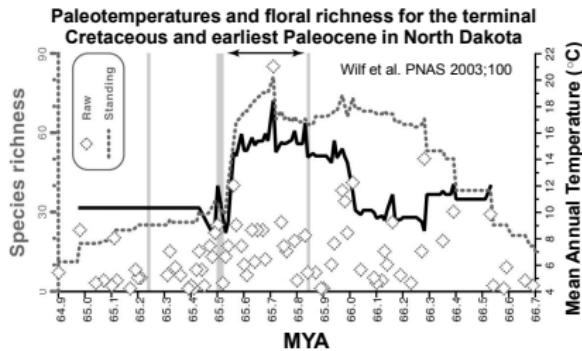
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- Loss or collapse of ecosystem function



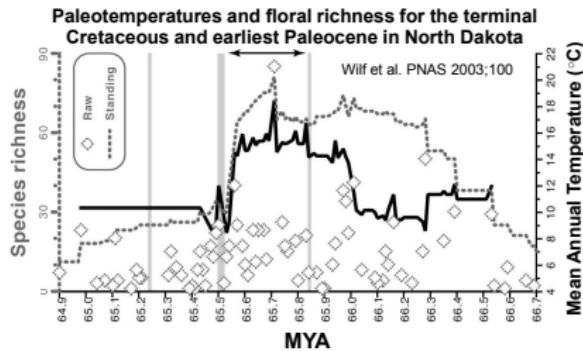
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- Loss of ecosystem recovery or succession



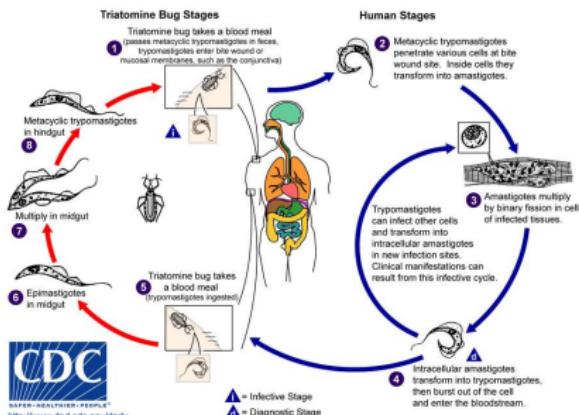
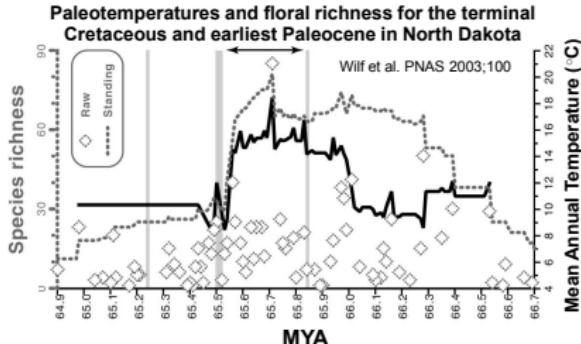
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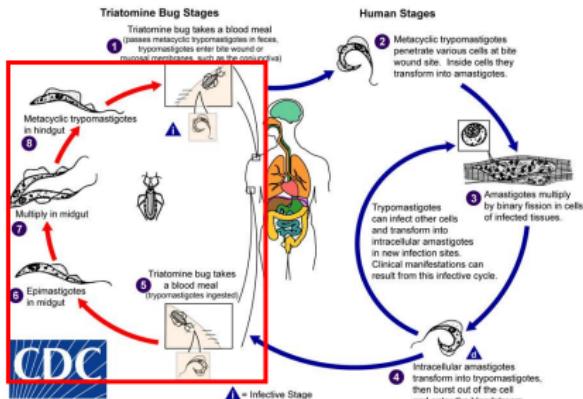
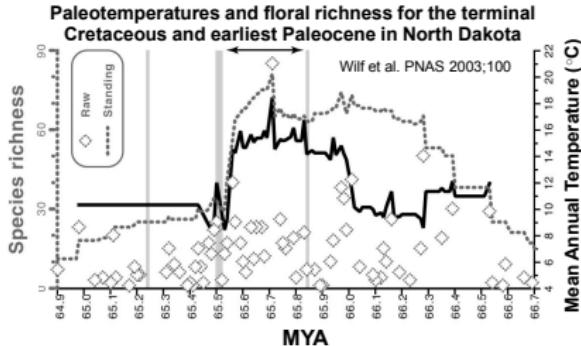
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- Loss or collapse of ecosystem function
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- Disease emergence & outbreak



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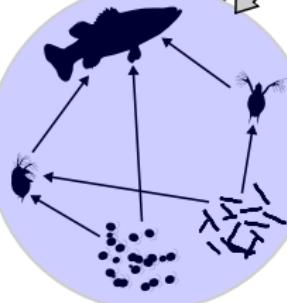
## Individuals

*System*  $\Rightarrow$  Metabolic rate & fitness

Traits: Body size, Thermal sensitivity, Respiration rate, Body velocity, etc.



- Generalities and deviations in metabolic and biomechanical traits
- Evolution of thermal responses and origins of physiological mismatches



## Interaction networks

*System*  $\Rightarrow$  Multi-population dynamics & community stability

Traits: Encounter & Attack rates, Handling time, Physiological mismatch, etc.



- Biomechanics of interaction rates
- Consequences for consumer-resource and competitive dynamics (including invasions)

## Interactions

*System*  $\Rightarrow$  Coupled population dynamics & mean fitness

# WHY Computational ECOLOGY AND EVOLUTION?

*Open access, freely available online*

Essay

## Mathematics Is Biology's Next Microscope, Only Better; Biology Is Mathematics' Next Physics, Only Better

Joel E. Cohen

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Essay

## **Mathematics Is Biology's Next Microscope, Only Better; Biology Is Mathematics' Next Physics, Only Better**

Joel E. Cohen

**Read it!** (its on blackboard)

# WHY Computational ECOLOGY AND EVOLUTION?

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- Need reproducible analyses and work-flows that link theory, data, analyses

ergo, Computing!



# BUT ABOVE ALL, IT'S ABOUT THE BIOLOGY!

*It is hard for me to say confidently that, after fifty more years of explosive growth of computer science, there will still be a lot of fascinating unsolved problems at peoples' fingertips, that it won't be pretty much working on refinements of well-explored things. Maybe all of the simple stuff and the really great stuff has been discovered. It may not be true, but I can't predict an unending growth. I can't be as confident about computer science as I can about biology. Biology easily has 500 years of exciting problems to work on, it's at that level.*

(Donald Knuth)

# OK, BUT WHY COMPUTATIONAL ECOLOGY AND EVOLUTION AT *Silwood*?

A wide range of theoretical and empirical research (big data!):

- Evolution and Developmental Genetics (Arkhat Abzhanov)
- Genetics and Behavior (Schroeder)
- Tropical biology (Ewers, Banks-Leite)
- Vector biology behavior and disease (Cator, Burt)
- Phylogenetics, genomics (Savolainen)
- Human genetics (Hodgson)
- Paleontology (Brazeau)
- Food webs, networks (Woodward, O'Gorman, Pawar)
- Metabolic theory, population biology (Pawar)
- Pollinator behavior and ecology (Gill)
- Neutral theory, scientific visualization (Rosindell)
- Population genetics (Lande)
- Conservation biology (Knight)
- Microbial systems (Bell, Barraclough, Raymond)
- Sexual selection and genomic conflict (Hollis)

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- Microbial systems (Bell, Barraclough, Raymond)
- Sexual selection and genomic conflict (Hollis)
- Lots more, and there are multiple campuses!

# WHAT YOU WILL LEARN

- Good competence in quantitative methods for addressing modern biological problems
- How to select a quantitative tool to address a biological problem
- An ability to develop, analyse, numerically simulate, fit models to data and interpret
- Quantitative models of biological systems, including statistical and mathematical (MSc) models
- Techniques in Population biology, Population genetics, genomics and GIS
- How you design and conduct research, with the necessary computational workflows – *please have a look at past projects!*

*Note that MSc's have about double the coursework in these areas*

**Alright!, Alright!, I am convinced...**

**Alright!, Alright!, I am convinced...**

**but show me the real stuff!**

# COURSE ADMINISTRATION

<i>Course Director</i>	Dr. Samraat Pawar (ext. 42213, s.pawar@imperial.ac.uk)
<i>Course Co-Director</i>	Dr. James Rosindell (ext. 42242, j.rosindell@imperial.ac.uk)
<i>Postgraduate Administrator</i>	Mrs. Amanda Ellis (ext. 42251, amanda.ellis@imperial.ac.uk)
<i>Postgraduate Tutor</i>	Dr. Julia Schroeder (ju- lia.schroeder@imperial.ac.uk)
<i>Director of Postgraduate Studies</i>	Dr. Niki Gounaris (ext. 4 5209, k.gounaris@imperial.ac.uk)
<i>Course Tutor</i>	Mr. Vignesh (Kartik) Chundru (vig- nesh.chundru14@imperial.ac.uk)
<i>Course Representative</i>	Up to you (see handbook)

Add 020 759 to extension numbers to call from external phones

# COMPUTER SETUP

- You each should receive a computer, bag, mouse, keyboard, room key, power supply, stand if you want it
- Turn it on – its Ubuntu 14.04 64 bit
- If you are using your own laptop – use Ubuntu 14.04 64 bit or higher
- Make sure you can:
  - Access secured imperial wireless (use college name and password)
  - Access the library website
  - Access Blackboard (bb.imperial.ac.uk) and give it a spin
- Get an account at bitbucket.org using your imperial college account, read their Git tutorials (very intuitive!)
- You will be assisted by very capable demonstrators – also, learn collaboratively with your classmates!

# COMPUTER GUIDELINES AND RULES

- You are responsible for your computer hardware and software
- You should be able to install all necessary (open source) software
- Your computer is your tool, you are expected to achieve a high degree of mastery of it!
- You return it to Imperial at end of year
- We expect it to be undamaged
- Please lock Seminar room 2 (we will keep it open for study) when not in it – should happen automatically (talk to Jim Culverhouse)
- Please do not leave your computer in any room (other than your residence!) overnight, starting now

# HANDBOOK AND LECTURES

- Printed handbooks may become outdated, download updated ones from the bitbucket repo
- Please check key dates for coursework and reports
- Lectures:
  - 2 1-hr lectures in the morning (1000 – 1230, except in some cases)
  - 3-hour practical in afternoon, except on Wednesdays
  - Lecturers will stay for at least 1 hour of practical session
  - There may be deviations from this – check updated timetables!
  - Usually one more demonstrators will be available during practicals
  - All lectures in this room (Wallace), except where noted

# SEMINARS

- Monday and Thursday seminars at 1300 hrs in this building
- Students must attend Thursday seminars – 1/2 page discussion each of min 16 seminars (seminar diary) due at end of course
- Monday seminars are internal, informal and optional (not been too active of late!)
- Monday seminars great for running ideas past peers (you can give multiple short ones)!
- Seminar web sites in handbook

# SEMINARS AND WORKSHOPS

- Workshops organized by us are all optional, but strongly recommended – check handbook
- Some important ones this week (**note:** tomorrow is one by me on research projects)
- In terms 2 and 3 you can organize additional workshops as and when needed
- Summer school on Frontiers in Ecology and Evolution (FrEE):
  - Week 3 of July, mainly organized by CMEE Masters, but we would like to expand it!
  - More details in handbook – come talk to us well in advance!

# ASSESSMENT AND MARKING

Activity	MSc CMEE	MRes CMEE
<i>Lectures + practicals, with assessment</i>	Required for first 17 weeks	Required for first 9 weeks, optional attendance in MSc modules within reason thereafter
<i>Exams</i>	Required	Not required
<i>Project report (Dissertation)</i>	Required	Required
<i>Seminars</i>	Required, seminar diary required for a minimum 16 weeks	Required, seminar diary required for a minimum 16 weeks
<i>Workshops</i>	All optional	All optional

# ASSESSMENT AND MARKING

Component	MSc CMEE		MRes CMEE	
	% of Course	% of Component	% of Course	% of Component
<b>Coursework</b>				
<i>Computing</i>	13.75	55	13.75	55
<i>Python Long Practical</i>	5	20	5	20
<i>HPC Long Practical</i>	5	20	5	20
<i>Seminar Diary</i>	1.25	5	1.25	5
<i>Coursework Total</i>	25	100	25	100
<b>Exams</b>				
<i>Exam 1</i>	10	40	–	–
<i>Exam 2</i>	15	60	–	–
<i>Exam Total</i>	25	100	–	–
<b>Project</b>				
<i>Proposal defense (Presentation + Proposal)</i>	2.5	5	–	–
<i>Project progress defence (Presentation + Report)</i>	–	–	7.5	10
<i>Final Report + Presentation</i>	32.5	65	45	60
<i>Viva</i>	12.5	25	18.75	25
<i>Supervisor mark</i>	2.5	5	3.75	5
<i>Project Total</i>	50	100	75	100

# IMPORTANT DATES

Date	Activity/Item due
9 December, 1PM	MRes: Project proposal
12 February, 12AM	MSc, MRes: HPC Long Practical submission
8 March, 1PM	MSc, MRes: Python Long Practical submission
4 April, 1PM	MSc, Project proposal; Mres, Project progress report
8 April	MSc, Project proposal presentation; MRes: Project progress presentation
Week 3 of July	FrEE Summer School
29 Aug, 5pm	MSc, MRes: Seminar Diary Submission
1 Sep, 5pm	MSc, MRes: Final project report electronic submission
5 Sep, 5pm	MSc, MRes: Final project report hard copy submission
15–16 Sep	MSc, MRes: Silwood Masters Symposium (final project presentations)
19–21 Sep	MSc, MRes: Internal vivas
22–23 Sept	MSc, MRes: External Examiner vivas

# WARM-UP FOR REST OF THE WEEK

- Lots of UNIX tutorials out there. Try  
<http://software-carpentry.org/lessons.html>  
(Chapter “shell”). ( watch video tutorials or read pdfs)
- Excellent book on Git: <http://git-scm.com/book>, also,  
<https://www.atlassian.com/git/>
- See <http://www.andy-roberts.net/writing/latex/benefits>
- Also, Word vs. L<sup>A</sup>T<sub>E</sub>X:  
[http://openwetware.org/wiki/Word\\_vs.\\_LaTeX](http://openwetware.org/wiki/Word_vs._LaTeX)

*More extensive list in handbook and Course notes (did you get my email?)*

# QUESTIONS?



*(soon to be) Famous CMEE Fungus*