Imperial College London

GCEE Grand Challenges

GRAND CHALLENGES IN ECOSYSTEMS AND THE ENVIRONMENT INITIATIVE

SCIENCE FOR THE LIVING PLANET

REPORT 2013–2018
PROFESSOR VINCENT SAVOLAINEN

FOREWORD

Planet Earth is facing unprecedented environmental challenges due to human expansion, yet our current understanding of the planet's complex systems is mostly insufficient for science-based intervention.

Since its launch in October 2013, the Grand Challenges in Ecosystems and the Environment (GCEE) Initiative has served as a global hub for addressing global environmental challenges for human wellbeing, carrying out world-leading science with a focus on finding solutions to four global challenges in a collaborative manner, at an interface between science, practitioners and policy makers.

With headquarters in Life Sciences at the Silwood Park Campus, GCEE aimed to bring together researchers from across the College to tackle these problems, including Life Sciences of course, but also the Centre for Environmental Policy, the School of Public Health, Civil and Environmental Engineering and the Grantham Institute for Climate Change and the Environment to name just a few. Building networks with UK and international partners, we aimed to deliver truly global solutions to these challenges.

Here, highlights of our scientific and outreach activities have been compiled for the period 2013–2018, and our plan and aspirations are presented for the next two years.

My thanks go to former GCEE Directors Professors EJ Milner -Gulland and Rob Ewers, as well as to all GCEE members and advisers. The past few years have certainly been busy and have set strong foundations for the future of GCEE.

Professor Vincent Savolainen
Director of GCEE

£74M
of external grant income*

128
PhD students enrolled through the *Centre for Doctoral Training in Quantitative Method in Ecology and Evolution* (QMEE) led by GCEE and the *Doctoral Training Programme* (DTP) *in Science and Solution for a Changing Planet* co-led by GCEE, and other programmes**

781
Masters students based at Silwood Park from 50 countries

557
peer-reviewed scientific publications, of which 57 were in leading *Nature* and *Science* journals***

Six out of 11
impact case studies submitted by Imperial in biological sciences for the UK Research Excellence Framework (REF2014)

25
outreach events in just the last two years

*This is the full list of grants won by Silwood Park's Life Sciences staff ending after 1 January 2013 and including subcontracts

**(Co)director: Professor Tim Barraclough; funded by the UK Natural Environment Research Council, led by the Grantham Institute

****Nature, Nature Biotechnology, Nature Climate Change, Nature Communications, Nature Ecology & Evolution, Nature Plants, Science, Science Advances*

CHALLENGE 1: UNDERSTANDING BIODIVERSITY ORIGINS AND LOSSES

GLOBAL EFFECTS ON LOCAL BIODIVERSITY

Species numbers have decreased by an average of 14% wherever humans have altered the landscape, affecting the functioning of major ecosystems. Research led by Professor Andy Purvis has shown how human caused land-use changes, such as the growth of agriculture, plantations and urban centres, have caused a global fall in the numbers of species found in local ecosystems. The research is part of the *Projecting Responses of Ecological Diversity In Changing Terrestrial Systems* (PREDICTS) project, which has so far collated data from 90 countries and 450 scientific papers representing more than 40,000 species.

Nature 520:45, 2015

Great white sharks and tuna share genetics that makes them super predators (credit: Gelty Images USO)

UNDERSTANDING FISH PHYSIOLOGIES RELEVANT TO FISHERIES AND CONSERVATION BODIES

Tuna fish and the lamnid group of sharks, which includes great white sharks, share similar traits that help make them super predators, including their style of swimming and their ability to stay warm (endothermy). Despite their distant relationships, research led by Professor Vincent Savolainen reveals genes sometimes shared in the two groups that give them this predatory edge. Savolainen and his team also compared bluefin tunas that maintain elevated body temperatures and occupy cold, productive high-latitude waters, with less cold-tolerant yellowfin tuna, which reproduce more rapidly in warm-temperate to tropical waters year-round. These differences provide resilience in the face of large-scale industrial fisheries. Despite the importance of these traits to both fisheries and responses to climate change, little is known of the genetic processes underlying the diversification of tunas. In collecting and analysing sequence data across 29,556 genes, Savolainen found that parallel selection on standing genetic variation is associated with the evolution of endothermy in bluefin tunas.

Genome Biol. Evol. 8:3011, 2016; *Mol. Biol. Evol.* Online

FINDING NEW ANIMAL MODELS OF HUMAN DISEASES: COULD DEER HOLD CLUES ABOUT THE LINK BETWEEN MALARIA RESISTANCE AND SICKLE CELL?

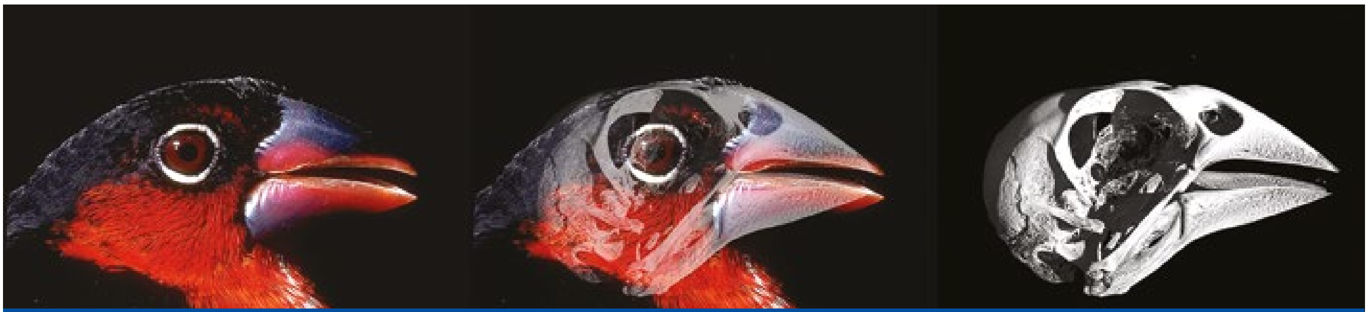
Scientists have identified the genetic mutations that cause sickle cells in deer. Although this research is in its early stages, it shows promise that certain species of deer might potentially be a surprising model in which to study the effects of sickling in humans such as resistance to malaria. The team of researchers led by Dr Tobias Warnecke from Imperial's Institute of Clinical Sciences, and which included Professor Vincent Savolainen from the GCEE, analysed the genetic make-up of sickled and non-sickled red blood cells in 15 species of deer, and compared them to our current knowledge of how the trait came about in humans. They found that the sickle trait in deer took a different evolutionary path to the trait in humans. Our results have implications for understanding the ecological regimes and molecular architectures that have promoted convergent evolution of sickling erythrocytes across vertebrates.

Nature Ecology & Evolution 2:367, 2018

LINKING DEVELOPMENTAL BIOLOGY AND BIODIVERSITY

The striking diversity of bird beak shapes is an outcome of natural selection, yet the relative importance of the limitations imposed by the process of beak development on generating such variation is unclear. Dr Arkhat Abzhanov showed that the dynamics of the proliferative growth zone during beak development must follow restrictive rules to explain the observed variation. His findings indicate that beak shape variability in many songbirds is strongly constrained by shared properties of the developmental programme controlling the growth zone.

Nature Comm. 5:3700, 2014



Computer tomography scans of the skulls of African Seedcracker (*Pyrenestes ostrinus*) overlaid with head images showing highly specialised skeletal morphology (credit: A. Abzhanov and C. Clabaut).

ANCIENT ENVIRONMENTS AND THE EVOLUTION OF JAWS IN VERTEBRATES

The phylogeny of Silurian and Devonian (443–358 million years ago) fishes remains the foremost problem in the study of the origin of modern jawed vertebrates. A central question concerns the morphology of the last common ancestor of living jawed vertebrates, with competing hypotheses advancing either a cartilaginous- or bony fish model. Dr Martin Brazeau described a new fossil from Siberia, *Janusiscus schultzei*, from approximately 415 million years ago, which provides important new information about cranial anatomy near the last common ancestor of cartilaginous and bony fish.

Nature 520:82, 2015

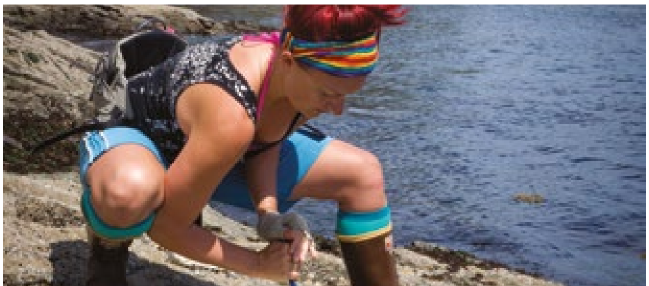
Tropical reefs in decidedly non-tropical places: Looking for evidence of a diverse fossil fish assemblage in a 420-million-year-old tropical reef and back-reef deposit in the Canadian Arctic (credit: M. Brazeau)

CHALLENGE 2: NEW APPROACHES TO ENVIRONMENTAL MONITORING AND EVALUATION

WARMING EFFECTS ON MARINE FAUNA

Dr Rebecca Kordas used miniature marine ecosystems and tested how they fared in experimentally warmed conditions. She found that in the hottest conditions, ecosystems that included limpets – voracious snail-like marine herbivores – fared the best. Other work showed that larger predators are also able to thrive in geothermally heated streams due to increased nutrient supply in warmer temperatures. This work helps to predict how ecosystems will respond to global warming.

Science Advances 3:e1701349, 2017



Dr Kordas working on her experiment, which demonstrated that herbivory enabled marine intertidal communities to resist warming (credit: Sean McGuire)

CONTROLLING BIOLOGICAL INVASIONS

Dr David Orme helped reveal the top factors in the spread of invasive bird species, providing scientists with a possible 'early warning system' for invasions. He investigated records of movement for nearly 1,000 bird species from the years 1500 to 2000, finding that human activities are the main determinants of how many alien bird species live in an area, but that alien species are most successful in areas already rich with native bird species.

PLoS Biology 15:e2000942, 2017

Above- and below-ground analysis of 137 intensively-monitored forests across 18 European countries revealed that environmental thresholds used as major ecosystem assessment tools need strong adjustment (credit M. Bidartondo and S. van der Linde)

POLLUTION HARMS FUNGI THAT NOURISH TREES

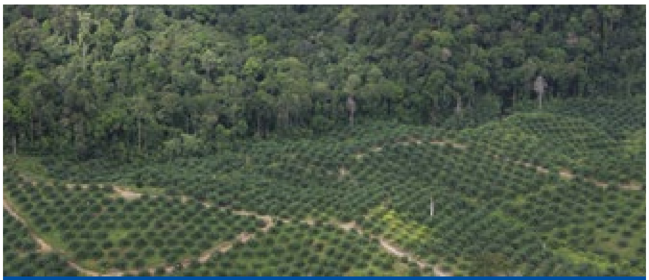
Explaining the large-scale diversity of soil organisms that drive biogeochemical processes—and their responses to environmental change—is critical. However, identifying consistent drivers of belowground diversity and abundance for some soil organisms at large spatial scales remains problematic. Dr Martin Bidartondo and Dr David Orme from GCEE investigated a major guild, the ectomycorrhizal fungi, across European forests at a spatial scale and resolution that is unprecedented, to explore key biotic and abiotic predictors of ectomycorrhizal diversity and to identify dominant responses and thresholds for change across complex environmental gradients. They found that environmental and host factors explain most of the variation in ectomycorrhizal diversity, that the environmental thresholds used as major ecosystem assessment tools need adjustment and that the importance of belowground specificity and plasticity has previously been underappreciated.

Nature 558:243, 2018

CREATION OF FOREST EDGES HAS A GLOBAL IMPACT ON FOREST VERTEBRATES

Forest edges influence more than half of the world's forests and contribute to worldwide declines in biodiversity and ecosystem functions. However, predicting these declines is challenging in heterogeneous fragmented landscapes. Professor Rob Ewers and Dr Cris Banks-Leite assembled a global dataset on species responses to fragmentation and developed a statistical approach for quantifying edge impacts in heterogeneous landscapes to quantify edge-determined changes in abundance of 1,673 vertebrate species. They showed that the abundances of 85% of species are affected, either positively or negatively, by forest edges. Smaller-bodied amphibians, larger reptiles and medium-sized non-volant mammals experienced a larger reduction in suitable habitat than other forest-core species. Their results highlight the pervasive ability of forest edges to restructure ecological communities on a global scale.

Nature 551:187, 2017



Forest edges, such as this one adjacent to a palm oil plantation in Borneo, restructure ecological communities around the world (credit: R. Ewers)

RECENT ASIAN ORIGIN OF CHYTRID FUNGI CAUSING GLOBAL AMPHIBIAN DECLINES

Globalized infectious diseases are causing species declines worldwide, but their source often remains elusive. Dr Matteo Fumagalli, in a study led by Professor Matthew Fisher from the School of Public Health at Imperial, used whole-genome sequencing to solve the spatiotemporal origins of the most devastating amphibian panzootic to date, caused by the fungus *Batrachochytrium dendrobatidis*. They traced the source of *B. dendrobatidis* to the Korean peninsula. They dated the emergence of this pathogen to the early 20th century, coinciding with the global expansion of commercial trade in amphibians, and they showed that intercontinental transmission is ongoing.

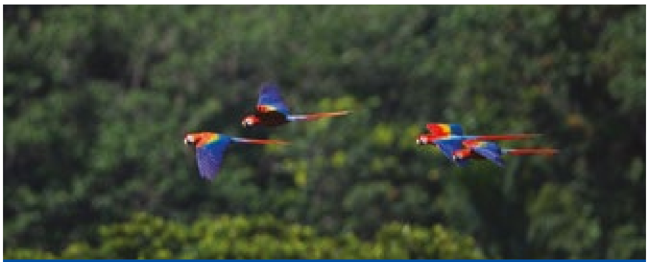
Science 360:621, 2018

Alytes muletensis with chytridiomycosis on the island of Mallorca. The chytrid fungus *Batrachochytrium dendrobatidis* is responsible for more than 200 amphibian species' extinction. Using genomic data, scientists discovered how it originated in Asia and how it spread across the world (credit: J. Bosch).

LONG-TERM DECLINE OF THE AMAZON CARBON SINK

Atmospheric carbon dioxide records indicate that the land surface has acted as a strong global carbon sink over recent decades, with a substantial fraction of this sink probably located in the tropics, particularly in the Amazon. Nevertheless, it is unclear how the terrestrial carbon sink will evolve as climate and atmospheric composition continue to change. Professor Jon Lloyd and colleagues analysed the historical evolution of the biomass dynamics of the Amazon rainforest over three decades using a distributed network of 321 plots. While this analysis confirms that Amazon forests have acted as a long-term net biomass sink, they found a long-term decreasing trend of carbon accumulation. The observed decline of the Amazon sink diverges markedly from the recent increase in terrestrial carbon uptake at the global scale, and is contrary to expectations based on models.

Nature 519:344, 2015



Although currently helping reduce rates of climate change through their sequestration of anthropogenic CO2 emissions, the strength of Amazon forest carbon sink is now declining (credit: J. Rosa)

CHALLENGE 3: ENGINEERING COMPLEX ECOSYSTEMS

CONTROLLING VECTOR-BORNE DISEASES

Diseases such as malaria, dengue fever, and Zika are estimated to impact the daily lives of 1/3 of the world population. The dramatic impact of these pathogens on their human hosts makes it easy to forget that they often spend much of their life cycle in another host: the mosquito. For many of these infections, the pathogen must undergo obligate life stages inside of a this small insect. Malaria parasites, for example, undergo sexual reproduction in the mosquito gut. Compared to the significant effort devoted to understanding the biology of malaria transmission from vertebrate hosts to mosquito vectors, the strategies that malaria parasites have evolved to maximize transmission from vectors to vertebrate hosts have been largely overlooked. Imperial researchers investigated strategies that may be deployed by the parasite inside of mosquitoes to maximize their likelihood of transmission and how these parasite life history attributes might affect public health interventions. This work was part of a transatlantic study into Vector Behaviour in Transmission Ecology (VectorBiTE) is being led by Dr Lauren Cator, to explore, analyse and model disease-carrying insect behaviour – potentially offering a better understanding of how diseases are spread.

Evolutionary Applications 11:456, 2018

Dr Andrew Aldersley inspects field cages to be used for experiments on mosquito mating behaviour with collaborators from the Armed Forces Research Medical Institute in Kamphaeng Phet, Thailand (credit: L. Cator)

Stakeholder engagement meeting with a local community on Target Malaria's project activities in Burkina Faso. ©Target Malaria.

EDITING THE GENOME OF MOSQUITOS TO CRACK MALARIA

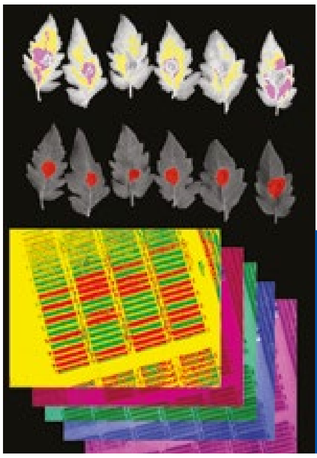
For decades, scientists have wondered about using genetic approaches to control vector-borne diseases, but only recently with the advent of new techniques for genome editing and synthetic biology has progress been made towards realising this goal. *Target Malaria* is a world-leading consortium of 15 institutions on three continents led by Professor Austin Burt that brings together molecular biologists, entomologists, population geneticists, mathematical modellers, and specialists in risk analysis, regulatory science and stakeholder engagement, all working towards the development of new tools to control the mosquitoes that transmit malaria in sub-Saharan Africa.

Nature Biotechnology 36:1062, 2018

NEW TECHNOLOGIES FOR EARLY DETECTION OF CROP DISEASES

Dr Oliver Windram is developing drone-mounted sensors that can detect plant disease before any visible signs show, allowing farmers to stop infections in their tracks. While these stresses are invisible to the naked eye, cameras using special filters can detect these subtle changes. He is partnering with industry to develop systems that help forecast *Septoria*, a key fungus affecting wheat, and believes the concept could later be adapted for other diseases. Dr Windram is also exploring genetic rewiring approaches to enhance plant stress tolerance and engineering microbial phenotypes.

Nucleic Acids Research 45:4984, 2017



Dr Windram uses a combination of reflectance spectrometry, multispectral imaging and machine learning to map plant disease in the lab and field, this helps enable early detection of asymptomatic fungal infections in crops (credit: O. Windram).

BEE RESEARCH TO HELP SUSTAINABLE FOOD PRODUCTION

With around three-quarters of the world's crop species relying on insect pollination to produce high yields, understanding the threats to insect pollinators is of paramount importance. Dr Richard Gill uses laboratory and field studies to develop strategies to mitigate bee declines. His work has revealed how pesticide exposure (namely the widely used neonicotinoids) can affect bee behaviour and colony development. His current work involves bringing together museum collections across UK and using ancient DNA, morphological analyses and micro CT scanning to predict population level responses to changing land use.

Scientific Reports 8:2045, 2018

HOW MUCH DOES IT COST TO SAVE ONE OF THE FEW WORLD' BIODIVERSITY HOTSPOTS?

How can the ecological gains of conservation be balanced against the economic costs of protecting nature? Dr Cristina Banks-Leite showed how ecological set-asides are a promising strategy to preserve biodiversity amidst human-modified landscapes. She demonstrated that an annual investment of less than 0.01% of Brazil's GDP would increase biodiversity and phylogenetic integrity across nearly eight million hectares of rural areas to a comparative level found in protected areas. Only rarely does economic feasibility meet ecological significance in conservation practices, yet it was shown that this is achievable in the Atlantic Forest of Brazil, a highly threatened biodiversity hotspot. These findings are leading to changes in regional and national land use policy.

Science 345:1041, 2014

Marsupials, like most other animals in the Atlantic forest of Brazil, are threatened of extinction (credit: C. Banks-Leite).

CHALLENGE 4: PREDICTING AND MITIGATING ENVIRONMENTAL CHANGE

NATURAL WARMING EXPERIMENTS TO UNDERSTAND GLOBAL CHANGE ON ECOSYSTEM FUNCTIONING

Natural ecosystems typically consist of many small and few large organisms. The scaling of this negative relationship between body mass and abundance has important implications for resource partitioning and energy usage. Global warming over the next century is predicted to favour smaller organisms, producing steeper mass–abundance scaling and a less efficient transfer of biomass through the food web. Dr Eoin O'Gorman and Professor Guy Woodward showed that the opposite effect occurs in a natural warming experiment involving 13 whole-stream ecosystems within the same catchment, which span a temperature gradient of 5–25 °C. The results will help to refine predictive models of ecosystem change.

Nature Climate Change 7:659, 2017

Natural warming experiment in Iceland (credit: G. Woodward)

FINDING FOOD IN A HOT CLIMATE

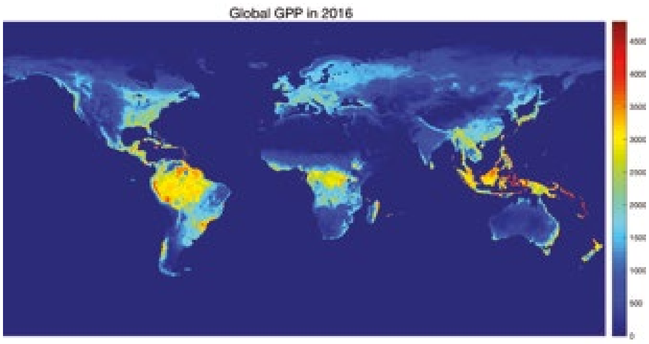
Dr Samraat Pawar and colleagues from the Zoological Society of London used metabolic theory, validated with large-scale data compilation, to predict how different organisms will respond to environmental change. For example, medium-sized carnivores spend the most time looking for food, making them more vulnerable to environmental change than large or small carnivores. Mammalian predators spend a significant part of their day foraging for food, and the more time they spend, the more energy they use. This makes predators that spend a long time foraging more vulnerable to changes in the environment that affect their primary resource: their prey.

Nature Ecology & Evolution 2:247, 2018

MATHEMATICS TO HELP MODELLING ECOSYSTEMS FROM FIRST PRINCIPLES

Professor Colin Prentice developed a radically new approach to modelling primary production worldwide. The model consists of a single equation applicable to all plants that use the ancestral C3 photosynthesis. Professor Prentice has also developed a model for leaf energy balance which explains, for the first time, the latitudinal gradient of leaf size – an outstanding mystery since the late nineteenth-century. His research aims to improve quantitative understanding of biotic feedbacks in order to improve global climate models, in collaboration with colleagues at Imperial's Department of Physics. Professor Prentice is also involved in a European Space Agency project *TerrA-P* to develop a new first-principles global monitoring system for primary production on land and was recently awarded an ERC Advanced Grant to further delve into this problem.

Nature Plants 3:734, 2017; *Science* 357:917, 2017



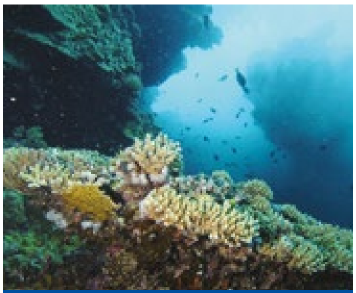
Modelled spatial pattern of gross carbon uptake by plants, in grams per square metre, during 2016 (credit: W. Cai).

Laboratory and field experiments have been used to discover how microbial communities respond to environmental change (credit: T. Bell).

METABOLIC THEORY TO PREDICT ECOSYSTEM RESPONSES TO GLOBAL CHANGE

Dr Samraat Pawar is developing metabolic theory for predicting the dynamics of ecological systems across multiple scales: food webs and climate change, disease vectors and biocontrol. The models are parameterised and validated using the *BioTraits* database, compiled by an international team of researchers and hosted by GCEE. The models are being applied to emerging data from field experiments at Silwood Park and beyond. Professor Barraclough and Dr Bell are developing metabolic models for predicting evolution and its effects on ecosystem functioning in microbial communities.

Nature Ecology & Evolution 2:1531, 2018; *ISME Journal* 10:2259, 2016



A coral reef in Egypt illustrating a highly biodiverse system that is both important and challenging to simulate (credit: J. Rosindell)

SIMULATING A BIODIVERSE WORLD

Dr James Rosindell is developing neutral theory simulations to predict biodiversity patterns ranging from extinction on oceanic islands, to fragmented tropical forests, to global biodiversity patterns. Recent work, funded by the Leverhulme Trust, is extending the so-called *Madingley General Ecosystem* Model to incorporate separate species in order to devise global models predicting changes to species richness.

Ecology Letters 21:804, 2018

BEING SMART ABOUT 'SMART' ENVIRONMENTAL TARGETS

Global progress toward meeting the Convention on Biological Diversity Aichi targets has recently been found wanting. The Aichi targets were intended to be SMART (specific, measurable, ambitious, realistic, and time-bound), partly in response to the perception that failure to meet the preceding global biodiversity targets resulted from their lack of SMART-ness. In this context, some argue that scientists must engage with the Sustainable Development Goals negotiation process to ensure that the environmental targets are not vague, modest, or lacking in detailed quantification. Dr Andrew Knight, Professor E. J. Milner-Gulland and colleagues cautioned against focusing only on ensuring that environmental targets are SMART and called for greater attention on the processes that lead to a target being set and met.

Science 347:1075, 2015

EFFECTS OF WETLAND SALINITY ON ANIMAL MIGRATIONS

Salinization is having a major impact on wetlands and its biota worldwide. Specifically, many migratory animals that rely on wetlands are increasingly exposed to elevated salinity on their nonbreeding grounds. Experimental evidence suggests that physiological challenges associated with increasing salinity may disrupt self-maintenance processes in these species. Dr Julia Schroeder investigated the extent to which the use of saline wetlands during winter induces residual effects that carry over and influence physiological traits relevant to fitness in a bird species (*Limosa limosa*) on their northward migration. They found that overwintering males and females were segregated by wetland salinity in West Africa, with females mostly occupying freshwater wetlands. These findings provide a window onto the processes by which wetland salinity can induce carry-over effects and can help predict how migratory species should respond to future climate-induced increases in salinity.

Scientific Reports 7:6867, 2017

Catching birds on an Andalusian rice field (credit: J. Schroeder).

REDUCTIONS IN GLOBAL BIODIVERSITY LOSS PREDICTED FROM CONSERVATION SPENDING

Halting global biodiversity loss is central to the Convention on Biological Diversity and United Nations Sustainable Development Goals, but success to date has been very limited. A critical determinant of success in achieving these goals is the financing that is committed to maintaining biodiversity; however, financing decisions are hindered by considerable uncertainty over the likely impact of any conservation investment. For greater effectiveness, we need an evidence-based model that shows how conservation spending quantitatively reduces the rate of biodiversity loss. Dr Joe Tobias and colleagues demonstrated such a model, and empirically quantified how conservation investment reduced biodiversity loss in 109 countries, by a median average of 29% per country between 1996 and 2008. Their model offers a flexible tool for balancing the Sustainable Development Goals of human development and maintaining biodiversity, by predicting the dynamic changes in conservation finance that will be needed as human development proceeds.

Nature 551:364, 2017

A study of conservation spending showed how $14 billion were allocated worldwide to protect threatened species, such as snow leopards (credit: Tambako The Jaguar, source: Flickr)

SILWOOD PARK: AN OUTDOOR LABORATORY FOR THE SCIENCE COMMUNITY AT LARGE

The Silwood Park campus is home to many field experiments: some spanning decades, others recently started and planned to last for many years into the future. GCEE has invested £3.5 million in new laboratories to support field experiments, including a microbial ecology and evolution laboratory with liquid handling robots, an ecological genomics laboratory funded by a Royal Society Wolfson Refurbishment Grant, new Controlled Environment rooms to replace ageing infrastructure, and an aviary to complement wild bird studies.

http://www.imperial.ac.uk/silwood-park/research/silwood-lte/

LONG-TERM TERRESTRIAL PLOTS

Dr Tom Bell and Professor Jason Tylianakis (University of Canterbury, New Zealand) are examining the impacts of alternative agricultural treatments on soil microbes, taking advantage of 30-year old experiments established by emeritus Professor Mick Crawley. Other plots form part of the *Nutrient Network (NutNet)* of 40 long-term grassland sites worldwide, examining the limits that soil nutrients place on grassland diversity and productivity.

Artificial ponds (mesocosms) at Silwood Park are used to study the effect of global warming on ecosystem function (credit: G. Woodward)

ARTIFICIAL PONDS (MESOCOSMS)

GCEE is a founding partner in a new Europe-wide network of aquatic ecosystem experiments stretching from the Arctic to the Mediterranean. The network will perform the first systematic large-scale experiments to compare how both freshwater and marine ecosystems respond to environmental pressures, including climatic change and other effects of the growing human population. It includes 21 institutions across 12 countries, and will bring together research using mesocosms – containers in which large volumes (1–1000 m^3) of water are enclosed and manipulated for experiments. At Silwood Park, the work was launched with a £3.7m NERC Large Grant funding a facility of 96 pond mesocosms that links over 30 project partners and visiting researchers from ten countries, plus collaboration with Syngenta on agroecosystems and freshwater pollutants

NEW DNA TECHNOLOGIES

Collaborations with the Departments of Civil and Environmental Engineering, Aeronautics and Dyson School of Design Engineering are developing new drone technology and acoustic recording devices for sampling physical and biological environmental changes in response to habitat modification. GCEE members are also developing environmental DNA methodology (eDNA) to track biodiversity and ecosystem functioning: Professor Vincent Savolainen and his group are tracking invasive species with Thomson Ecology, a leading ecological consulting firm, while Professor Alfried Vogler co-founded *NatureMetrics*, a start-up delivering eDNA services commercially. At a very different scale, Dr Richard Gill's group is helping to advance micro-CT scanning technology, allowing them to explore the effects of pesticides on the structure of bee brains.

A new laboratory for ecological genomics, funded by a Royal Society Wolfson Refurbishment Grant, is now open to scientists and students involved in environmental DNA research (credit: T. Angus)

School children learning about bees at Bugs! Day 2018. (credit: T. Angus)

GCEE@SILWOOD: AN OUTREACH PLATFORM OPEN TO LOCAL COMMUNITIES

GCEE runs events with local schools, youth organisations and conservation charities creating the opportunity for groups and individuals of all ages to connect with nature, to have hands-on experience in ecology and conservation work, and to learn about GCEE research and natural resources. Silwood park's students and staff have established strong partnerships with local and national charities to support conservation initiatives that aim to increase knowledge, preserve and restore the local green infrastructure. For example, work with Wildlife in Ascot, a group of residents working with the community has led to several events ranging from informative talks to wildlife surveys. We also participate in the Saving the Salt Hill Stream project. During the Slough's Play Day along with the Wetland Wildlife Trust and Slough Borough Council, we ran a Bioblitz inviting local residents to record all living species in the park and learn about the local environment.

Slough's Bioblitz with Silwood students helping inventrory species in the local area. (credit: T. Dunn)

WELCOMING OUR LOCAL COMMUNITY

Our annual Bugs! Day now attracts more than 500 people, where visitors enjoy a host of exhibits, demonstrations and bug-hunts. GCEE scientists and students present interactive activities that give people of all ages and backgrounds the chance to get hands-on and discover the ground-breaking research being carried out, and to hunt for wildlife in the grassland, woodlands and ponds of Silwood Park.

SCIENCE WITH SCHOOLS

Students from Charters School, Sunningdale have been involved in our onsite pond mesocosms project. In 2017 Charters was awarded a Royal Society Partnership grant to enable students, aged 5 – 18, to carry out science, technology, engineering or mathematics (STEM) projects. Working collaboratively with researchers allow the students to experience how the science that they are learning in school can be applied to solve complex problems.

GCEE PLAN & ASPIRATIONS 2019–2020

RESEARCH:

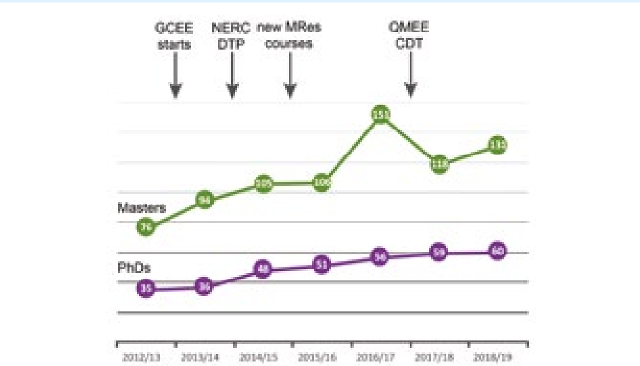
- Continue to produce outstanding science-based solutions to help resolve global challenges facing planet earth
- Seek funding to run workshops and establish an international visitor programmes
- Make a significant contribution to the REF2020 (research outputs and impact case studies), including appointing new academic staff to push forwards strategic areas such as sustainable food supply

TEACHING:

- Strengthen our portfolio of Masters courses and increase the number of students that join them
- Open up international short courses, e.g. funded by EMBO or other sources, to publicise GCEE and to benefit our students and postdocs community
- Develop short courses and training for researchers and practitioners in developing countries in which we work (e.g. big data and biodiversity analysis)

OUTREACH:

- Organise a VIP event focusing on 'science for the living planet', inviting local VIPs from around Ascot and Windsor, and involving other groups and bodies across College, to showcase our activities and vision
- Broaden *Bugs!* Day to be a celebratory day for locals of all ages, with adult activities in the evening in addition to schools during the day, working with local council, schools, organisations, to publicise the place and our science with the wider public
- Invite our alumni to these events to celebrate these successes with us



The number of PhD and Masters students registered on 1st January of each academic year since 2013. Masters students spend one year in department. PhD students spend 3.5 years and hence the same student is counted in multiple years. (credit: T. Barraclough)

ENGAGE WITH US

GCEE is always looking to involve dynamic individuals with innovative ideas and a drive to tackle Grand Challenges.

Why not spend your sabbatical with us? We welcome applications from individuals in any related sector. Furthermore, we are eager to create new working relationships that unite different communities, industry and academia together, and would particularly encourage businesses to contact us.

Contact:
Professor Vincent Savolainen, v.savolainen@imperial.ac.uk