IMPERIAL

Georgina Mace Centre for the Living Planet

Report 2024

Professor Vincent Savolainen

Foreword

Imperial's Georgina Mace Centre (GMC) for the Living Planet continues to address some of the most pressing environmental challenges facing the world today.

The Centre is named in honour of Professor Dame Georgina Mace FRS, whose pioneering work on the development of universal criteria for listing threatened species on the International Union for Conservation of Nature's Red List has had a profound global impact. Her contributions played a key role in shaping the 2002 commitments made by global signatories to the United Nations Convention on Biological Diversity.

This year has been another significant and productive one for the Centre. A memorable highlight was the annual Georgina Mace Centre Debate, which examined the effectiveness of international targets and treaties and explored ways to improve their outcomes. Held on 18 July at Imperial's Silwood Park campus, the debate drew inspiration from COP28 and focused on the ambitious "30 by 30" initiative – the global target of protecting 30% of the planet's land and oceans by 2030. This critical discussion brought together policymakers and scientists to explore the feasibility of achieving this target and the challenges that might hinder progress. It also provided an opportunity to exchange ideas on mobilising action and advancing science-based solutions to secure a sustainable future for our planet.

The debate began with an introduction from Professor Maggie Dallman, Imperial's Vice-President (International), followed by welcoming remarks from Centre Co-Directors Professor Vincent Savolainen and Professor Mat Fisher. These introductions set the stage for engaging presentations by an exceptional panel of speakers: Professor Richard Bardgett from the University of Manchester, Dr Mike Barrett from WWF-UK, Professor Dame EJ Milner-Gulland from the University of Oxford, and Professor Gideon Henderson, Chief Scientific Adviser at the Department for Environment, Food and Rural Affairs. After the talks, a lively Q&A session was chaired by Professor Guy Woodward, Deputy Head of Department at Silwood Park. The event concluded with a vote of thanks delivered by Professor Dan Davis, Head of the Department of Life Sciences.

Panel discussion, Georgina Mace Centre Debate 2024. Photo: Fergus Burnett.

Scientists of the future discover the wonder of carnivorous plants at Bugs, Birds & Beasts Day 2024. Photo: Brendan Foster.

In addition to its public events, the Centre has made strides in fostering collaboration and securing funding for impactful research initiatives. This year, the Centre obtained two grants from Research England's International Science Partnerships Fund, totalling £116,000. These grants will support a project on resilient coconut breeding for food security in West Africa, conducted in partnership with our African collaborators and CABI, an international NGO whose mission is to share agricultural and environmental knowledge to empower communities and protect the planet. CABI is moving its UK headquarters to Silwood Park, in an exciting move that further strengthens ties with the Centre.

The Centre has also worked on supporting innovative interdisciplinary research at the University. Dr Dante Kalise from Imperial's Department of Mathematics, along with Professor Savolainen, secured £25,000 from the Turner Kirk Trust Sprint Challenge, established to bring together conservation scientists and mathematicians to develop transformative and tangible solutions to some of the most difficult conservation problems facing us today. Their project, titled *Towards a Quantitative Understanding of Collective Animal Behaviour Under Climatic Events*, aims to use mathematical modelling to advance conservation science.

Community outreach remains a key focus for the Centre, exemplified by this year's *Bugs, Birds & Beasts Day*, held in July. The ever-popular event welcomed nature enthusiasts of all ages to Silwood Park, where they had the opportunity to engage with experts and activities led by various organisations, including Butterfly Conservation, Wildlife in Ascot, and the Berkshire Nature Recovery Strategy. Our new neighbours CABI provided a welcome contribution to the event by hosting a clinic where plant doctors provided advice on how to care for ailing plants.

Additional satellite outreach events took place throughout the year. Master's students from the Mammals Club organised two activities aimed at increasing knowledge about mammals: one for children at St. Michael's Primary School in Ascot, and another for the general public via an online workshop in April. The Sunningdale Beavers and Squirrels clubs participated in pond dipping and nature walks on four occasions in 2024. Each group consisted of approximately 10 children aged four to eight years.

In addition, a class of A-Level students from Bracknell & Wokingham College participated in a plant diversity exercise.

This year also saw significant infrastructure developments at Silwood Park, enhancing the Centre's research and collaborative spaces. A new 45 desk open-plan workspace was created on the ground floor, offering an inviting and dynamic environment for PhD students and postdoctoral researchers to interact and exchange ideas. Additionally, a state-of-the-art microbiology laboratory suite with 30 desks was opened in the Munro Building, located adjacent to the Centre.

As we reflect on the achievements of the past year, we remain dedicated to advancing our mission of fostering impactful research and collaboration to address critical environmental challenges. We look forward to building on these successes and driving new initiatives in the year ahead.

Professor Vincent Savolainen
Director

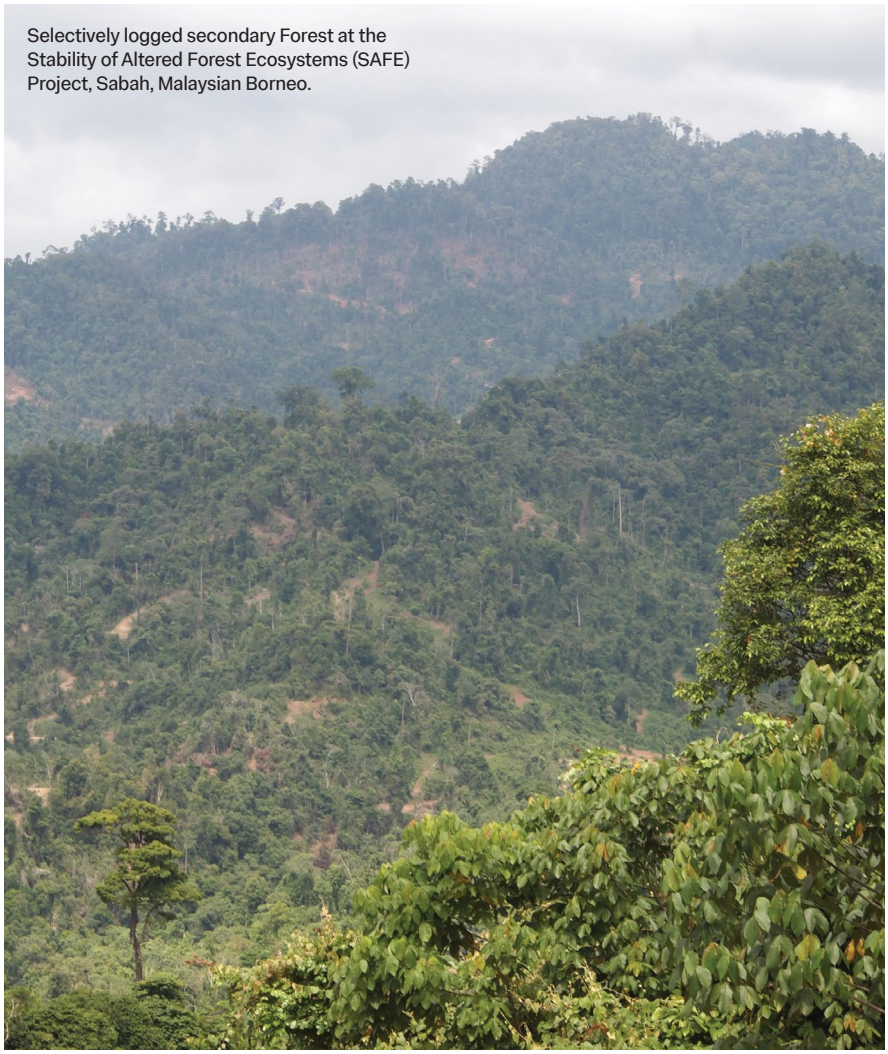
Professor Matthew Fisher
Co-Director

Research highlights

Thresholds for adding degraded tropical forest to the conservation estate

Logged and disturbed forests are often viewed as degraded and depauperate environments compared with primary forest. However, they are dynamic ecosystems that provide refugia for large amounts of biodiversity, so we cannot afford to underestimate their conservation value. Prof. Rob Ewers and 136 coauthors, several members of the GMC, presented empirically defined thresholds for categorising the conservation value of logged forests, using one of the most comprehensive assessments of taxon responses to habitat degradation in any tropical forest environment. They analysed the impact of logging intensity on the individual occurrence patterns of 1,681 taxa belonging to 86 taxonomic orders and 126 functional groups in Sabah, Malaysia. Their results demonstrate the existence of two conservation-relevant thresholds. First, lightly logged forests (<29% biomass removal) retain high conservation value and a largely intact functional composition, and are therefore likely to recover their pre-logging values if allowed to undergo natural regeneration. Second, the most extreme impacts occur in heavily degraded forests with more than two-thirds (>68%) of their biomass removed, and these are likely to require more expensive measures to recover their biodiversity value. Overall, their data confirm that primary forests are irreplaceable, but they also reinforce the message that logged forests retain considerable conservation value that should not be overlooked.

***Nature* 631:808 (2024)**



Selectively logged secondary Forest at the Stability of Altered Forest Ecosystems (SAFE) Project, Sabah, Malaysian Borneo.

Key indicators

£ 89.5 M
of external grant income*

48 PhD students
based at Silwood Park**

72 Masters students
based at Silwood Park from 15 countries

456 peer-reviewed scientific publications,
of which over 40 were in leading *Nature* and *Science* journals***

12 Outreach Events**

Professor Mat Fisher won the Marsh Award for Conservation Biology

*This is the full list of grants won by Silwood Park's Life Sciences staff ending after 1 January 2023 and including subcontracts. It includes £ 5.55 M won by Silwood Park's Life Sciences staff starting after 1 January 2024.

** PhD Students enrolled through the Centre for Doctoral Training in Quantitative Method in Ecology and Evolution and Doctoral Training Programme in Science and Solution for a Changing Planet, and other programmes

***Nature, Nature Communications, Nature Biotechnology, Nature Catalysis, Nature Climate Change, Nature Ecology & Evolution, Nature Medicine, Nature Immunology, Nature Microbiology, Nature Reviews, Nature Sustainability, and Science

**** Master Students Mammals Club, Students Work Experience, Sunningdale Beavers and Squirrels Clubs, Bugs, Birds & Beasts Day

Scientists have long shown that climate change is affecting the sustainability of life on earth.

Phylogenetic estimates of species-level phenology improve ecological forecasting

The ability to adapt to climate change requires accurate ecological forecasting. Current forecasts, however, have failed to capture important variability in biological responses, especially across species. Dr Will Pearse and co-workers presented a new method using Bayesian hierarchical phylogenetic models and show that species-level differences are larger than the average differences between cues. Applying their method to phenological experiments manipulating temperature and day length they show an underlying phylogenetic structure in plant phenological responses to temperature cues, whereas responses to photoperiod appear weaker, more uniform across species and less phylogenetically constrained. They thus illustrate how a focus on certain clades can bias prediction, but that predictions may be improved by integrating information on phylogeny to better estimate species-level responses. Their approach provides an advance in ecological forecasting, with implications for predicting the impacts of climate change and other anthropogenic forces on ecosystems.

***Nature Climate Change* 14:989 (2024)**

Antarctic krill sequester similar amounts of carbon to key coastal blue carbon habitats

The carbon sequestration potential of open-ocean pelagic ecosystems is vastly under-reported compared to coastal vegetation 'blue carbon' systems. Dr Emma Cavan and co-workers showed that just a single pelagic harvested species, Antarctic krill, sequesters a similar amount of carbon through its sinking faecal pellets as marshes, mangroves and seagrass. Due to their massive population biomass, fast-sinking faecal pellets and the modest depths that pellets need to reach to achieve sequestration (mean is 381 m), Antarctic krill faecal pellets sequester 20 MtC per productive season (spring to early Autumn). This is equates USD$ 4 – 46 billion depending on the price of carbon, with krill pellet carbon stored for at least 100 years and with some reaching as far as the North Pacific. Antarctic krill are being impacted by rapid polar climate change and an expanding fishery, thus krill populations and their habitat warrant protection to preserve this valuable carbon sink.

***Nature Communications* 15:7842 (2024)**

Antarctic krill from the krill research aquarium at the Australian Antarctic Division. Photo: Anona Griffiths.

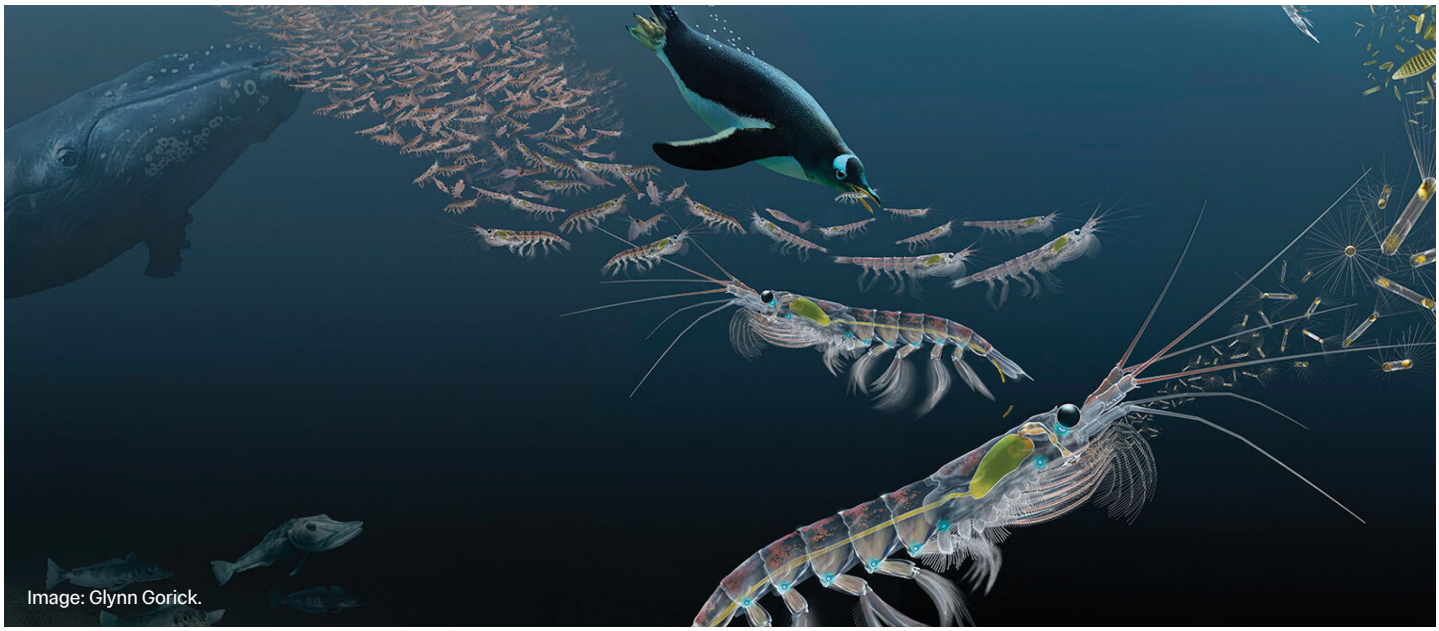


Image: Glynn Gorick.

Mosquitoes are collected from the sheets after PSC in Burkina Faso.
Photo: Target Malaria.

The potential of gene drives in malaria vector species to control malaria in African environments

Gene drives are a promising means of malaria control with the potential to cause sustained reductions in transmission. In real environments, however, their impacts will depend on local ecological and epidemiological factors. Dr Penelope Hancock and several members of the GMC developed a data-driven model to investigate the impacts of gene drives that causes vector population suppression. They simulated gene drive releases in sixteen ~12,000 km2 areas of west Africa that span variation in vector ecology and malaria prevalence, and estimated reductions in vector abundance, malaria prevalence and clinical cases. Average reductions in vector abundance ranged from 71.6–98.4% across areas, while impacts on malaria depended strongly on which vector species were targeted. When other new interventions including RTS,S vaccination and pyrethroid-PBO bednets were in place, at least 60% more clinical cases were averted when gene drives were added, demonstrating the benefits of integrated interventions. Their results show that different strategies for gene drive implementation may be required across different African settings.

Nature Communications **15:8976 (2024)**

The mould *Aspergillus fumigatus*.
Photo: Jennifer Shelton

Elevated mutation rates in multi-azole resistant *Aspergillus fumigatus* drive rapid evolution of antifungal resistance

The environmental use of azole fungicides has led to selective sweeps across multiple loci in the *Aspergillus fumigatus* genome causing the rapid global expansion of a genetically distinct cluster of resistant genotypes. Isolates within this cluster are also more likely to be resistant to agricultural antifungals with unrelated modes of action. Prof. Matt Fisher and co-workers showed that this cluster is not only multi-azole resistant but has increased propensity to develop resistance to next generation antifungals because of variants in the DNA mismatch repair system. A variant in msh6-G233A is found almost exclusively within azole resistant isolates harbouring the canonical cyp51A azole resistance allelic variant TR34/L98H. Naturally occurring isolates with this msh6 variant display up to 5-times higher rate of mutation, leading to an increased likelihood of evolving resistance to other antifungals. Furthermore, unlike hypermutator strains, the G233A variant conveys no measurable fitness cost and has become globally distributed. Their findings further suggest that resistance to next-generation antifungals is more likely to emerge within organisms that are already multi-azole resistant due to close linkage between TR34/L98H and msh6-G233A, posing a major problem due to the prospect of dual use of novel antifungals in clinical and agricultural settings.

Nature Communications **15:10654 (2024)**

Global conservation status of the jawed vertebrate Tree of Life

Human-driven extinction threatens entire lineages across the Tree of Life. Prof. James Rosindell and co-workers assessed the conservation status of jawed vertebrate evolutionary history, using three policy-relevant approaches. First, they calculated an index of threat to overall evolutionary history, showing that we expect to lose 86–150 billion years (11–19%) of jawed vertebrate evolutionary history over the next 50–500 years. Second, they ranked jawed vertebrate species by their EDGE scores to identify the highest priorities for species-focused conservation of evolutionary history, finding that chondrichthyans, ray-finned fish and testudines rank highest of all jawed vertebrates. Third, they assessed the conservation status of jawed vertebrate families. They found that species within monotypic families are more likely to be threatened and more likely to be in decline than other species. They provide a baseline for the status of families at risk of extinction to catalyse conservation action. This work continues a trend of highlighting neglected groups—such as testudines (turtles, terrapins, and tortoises), crocodiles, amphibians and cartilaginous fishes —as conservation priorities from a phylogenetic perspective.

***Nature Communications* 15:1101 (2024)**

Phylogenetic analyses point to turtles as particularly important for conservation efforts.

Tropical rainforest near the Ankasa study site, Ghana. Photo: Jesus Aguirre Gutiérrez.

Why models underestimate West African tropical forest primary productivity

Tropical forests dominate terrestrial photosynthesis, yet there are major contradictions in our understanding due to a lack of field studies, especially outside the tropical Americas. A recent field study indicated that West African forests have among the highest forests gross primary productivity (GPP) yet observed, contradicting models that rank them lower than Amazonian forests. Prof. Colin Prentice and co-workers showed possible reasons for this data-model mismatch. They found that biometric GPP measurements are on average 56.3% higher than multiple global GPP products at the study sites. The underestimation of GPP largely disappears when a standard photosynthesis model is informed by local field-measured values of (a) fractional absorbed photosynthetic radiation (fAPAR), and (b) photosynthetic traits. Remote sensing products systematically underestimate fAPAR (33.9% on average at study sites) due to cloud contamination issues. The study highlights the potential widespread underestimation of tropical forests GPP and carbon cycling and hints at the ways forward for model and input data improvement.

***Nature Communications* 15:9574 (2024)**

Variation in temperature of peak trait performance constrains adaptation of arthropod populations to climatic warming

The capacity of arthropod populations to adapt to long-term climatic warming is currently uncertain. Dr Lauren Cator, Prof. Samraat Pawar, and co-workers combined theory and extensive data to show that the rate of their thermal adaptation to climatic warming will be constrained in two fundamental ways. First, the rate of thermal adaptation of an arthropod population is predicted to be limited by changes in the temperatures at which the performance of four key life-history traits can peak, in a specific order of declining importance: juvenile development, adult fecundity, juvenile mortality and adult mortality. Second, directional thermal adaptation is constrained due to differences in the temperature of the peak performance of these four traits, with these differences expected to persist because of energetic allocation and life-history trade-offs. They compiled a new global dataset of 61 diverse arthropod species which provides strong empirical evidence to support these predictions, demonstrating that contemporary populations have indeed evolved under these constraints. Their results provide a basis for using relatively feasible trait measurements to predict the adaptive capacity of diverse arthropod populations to geographic temperature gradients, as well as ongoing and future climatic warming.

***Nature Ecology & Evolution* 8:500 (2024)**

Unidentified hemipteran. Photo: Samraat Pawar.

Many tropical birds are at risk of extinction.

The global loss of avian functional and phylogenetic diversity from anthropogenic extinctions

Humans have been driving a global erosion of species richness for millennia, but the consequences of past extinctions for other dimensions of biodiversity—functional and phylogenetic diversity—are poorly understood. Prof. Joe Tobias and co-workers showed that, since the Late Pleistocene, the extinction of 610 bird species has caused a disproportionate loss of the global avian functional space along with ~3 billion years of unique evolutionary history. For island endemics, proportional losses have been even greater. Projected future extinctions of more than 1000 species over the next two centuries will incur further substantial reductions in functional and phylogenetic diversity. These results highlight the severe consequences of the ongoing biodiversity crisis and the urgent need to identify the ecological functions being lost through extinction.

***Science* 86:55 (2024)**

Equality, diversity and inclusion

The Centre takes matters of equality, diversity, and inclusion very seriously. This year, Professor Savolainen and six international scholars published a comment arguing that a broader cultural view is necessary to study the evolution of sexual orientation.

Following a successful Royal Society–Theo Murphy scientific meeting on the 'Genetics and Evolution of Sexual Orientation' (27–28 March 2023), which inspired lively discussions that led to this comment, they highlight that the causation of sexual orientation is likely complex and influenced by multiple factors. They advocate incorporating a broader cultural perspective into evolutionary and genetic studies to account for differences in how sexual orientation is experienced, expressed, and understood in both humans and non-human animals.

The authors critically examine six commonly assumed but scientifically unfounded assumptions. Moreover, they suggest that in societies where same-sex behaviour is punished or shamed, individuals who desire such behaviour may instead pursue traditional marriage and child-rearing, thereby maintaining or even increasing the prevalence of these genetic or behavioural variants in the local population.

Consequently, they recommend integrating the scientific study of aversion to same-sex sexuality into research on sexual orientation to foster greater acceptance of sexual diversity.

***Nature Ecology and Evolution* 8:181 (2024)**

Imperial Dress the Rainbow fundraiser for Pride Month 2024.

Georgina Mace Centre plan and aspirations 2024–2025

Research

- Continue producing outstanding science-based solutions to address global challenges facing the planet.
- Facilitate the relocation of staff activities from other Imperial departments (beyond Life Sciences) to Silwood Park, following the successful engagement with the Department of Bioengineering.
- Strengthen collaborations with CABI as they establish their presence at Silwood Park.
- Publish an opinion paper in Philosophical Transactions of the Royal Society on the African perspective on biodiversity conservation. This follows the successful scientific discussion meeting organised at the Royal Society on 12–13 June 2023, titled "Bending the curve towards nature recovery: Building on Georgina Mace's legacy for a biodiverse future."

Teaching

- Expand the portfolio of Master's courses and increase the number of Master's students based at Silwood Park.
- Secure funding to support PhD students.

Outreach

- Organise a biodiversity debate at the House of Commons on sustainable agriculture, in collaboration with local MPs and other Imperial departments and faculties.
- Host a "Bugs, Birds & Beasts Day" including a theme of sustainable agriculture, with assistance from CABI.

Engage with us

The Georgina Mace Centre for the Living Planet is always looking to involve dynamic individuals with innovative ideas and a drive to tackle environmental 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.

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