



CONTENTS

Front cover: a red-footed booby (*Sula sula*) in the British Indian Ocean Territory, a region which is a major focus of ZSL scientific research. Below: angelsharks (*Squatina* sp.) are among the most endangered fish in European waters.

In 2018 we completed the first acoustic tagging survey of angelsharks in La Graciosa Marine Reserve off the Canary Islands to better understand their movements

Welcome	3
The Institute's global reach	4
Institute of Zoology news	6
Director's introduction	8

Impacts

Impact areas	9
Threatened species recovery and our long-term studies	10
Predictive ecology	12
Investigating emerging threats to garden wildlife health	14
Lessons from the past: historical baselines in conservation	16
Fostering coexistence between people and nature	18
Amphibian infections on the move	20

Highlights

Our highlights	23
Research highlights	24
How our science is done	28
Education and training	30
ZSL Library and scientific publications	33
Communicating science	34
ZSL Scientific Awards	36
Funding	37
Governance and staff	38



Welcome

The President and Director General of The Zoological Society of London present the *Institute of Zoology Review 2017-18*.

As President of The Zoological Society of London, I am pleased to introduce the *Institute of Zoology Review 2017-18*.

Habitats across the globe are facing unprecedented pressures – largely anthropomorphic – and it is the role of the Institute to interrogate the causes and effects of these changes so that they might be averted. One such habitat, islands, are at more risk than most, as their flora and fauna have evolved in relative seclusion and do not have the space nor the adaptability to meet these new changes. The Institute has taken a leading role in the protection and restoration of island species – from reintroductions of hihi in New Zealand to population management of the Mauritian kestrel or genetic monitoring of the Sumatran tiger – and places rigorous scientific practice at the very centre.

Putting all habitats at risk, from island to tundra alike, is the threat of climate change – and the Institute sits at the forefront of understanding its current and future impacts. Using pioneering predictive models and satellite data, our scientists are determining how different species and ecosystems could be affected. Sadly, research shows that birds and mammals are declining in areas of the world where warming has been most rapid.

The impact of our warming climate, habitat loss, pollution and countless other pressures can only be measured against existing benchmarks. Modern ecological data only provide a recent snapshot, filtering our knowledge of ecosystems through the lens of the Anthropocene. Our research into conservation palaeobiology has yielded exciting results, including the discovery of the world's largest bird – now extinct – and past populations of the Père David's deer, giving us insights into human and wildlife activity millennia ago.

This review presents six key impact areas where our research is making a difference to conservation and increasing our understanding of the natural world. Thank you for the tireless work of those involved.

We are a unique organisation, with the skillset and passion to drive the conservation agenda forward in the UK and overseas; to change the rules at a policy level in favour of wildlife. And our science is at the very core of this endeavour.

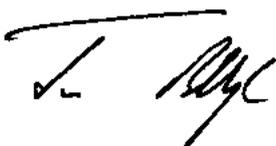
This year we launched ZSL 200, a new strategy for ZSL that gives us a clear vision for the future. It will allow us to refocus our efforts on areas where we can truly make impacts – one of which is wildlife health, where ZSL already demonstrates deep expertise.

Our scientists continue to investigate chytridiomycosis, the lethal disease threatening the collapse of worldwide amphibian populations, and are working to understand what impacts the spread of infection so that we might utilise those forces to our own advantage.

In the UK, our Garden Wildlife Health initiative has harnessed the power of the public, enabling us to monitor diseases affecting our native wildlife and issue advice to government and the public. On page 8 you can read further about how wildlife health will play a central role in our work, through the development of a new science campus.

Engagement is also a vital part of ZSL 200, and we will seek to empower communities, leaders and influencers by giving them the tools and knowledge they need to ensure wildlife thrives. We communicate science through a range of channels, from Soapbox Science events – a global initiative placing incredible women scientists in the spotlight to inspire future generations – through to our activities at events such as the Royal Society's Summer Science Exhibition, our publications and our public lectures.

It has been my great pleasure to take the reins of this inspiring and diverse Society, and I look forward to your support as we ensure ZSL finds answers to some of the greatest challenges facing wildlife today and in the future.



Professor Sir John Beddington CMG, FRS
President, The Zoological Society of London



Dominic Jermy CVO, OBE Director General,
The Zoological Society of London

The Institute's global reach



A Greenland

The deep sea is the largest habitat on Earth, but also one of the least known. We have been working in Greenland since 2011 to document, map and assess life on the deep seabed along the western continental shelf. We have found a variety of habitats, including coral gardens, sea-pen fields and cup-coral meadows, and have been assessing how vulnerable these are to the impacts of trawl fishing – an activity known to damage seabed habitats around Greenland. We are working with fisheries to implement measures to protect these vulnerable habitats, such as changing fishing gear and creating new protected areas closed to fishing.



B Ecuador

The Galápagos Islands off Ecuador are famous for their endemic bird community, which remains largely intact, having suffered very few species extinctions. However, the threat of introduced diseases poses a substantial risk to continued conservation efforts. Of particular concern is the recent discovery of the avian malaria parasite in endemic birds for the first time. Institute researchers, in partnership with the Galápagos Biosecurity Agency and Galápagos National Park, are working to understand how the parasite is transmitted in the islands, examining the roles of native and introduced mosquito species. This work will help inform conservation policy to deal with this potential threat.



Institute research is truly international – each dot on the map represents at least one scientific project. Here, we highlight six projects that illustrate the breadth of our work.



C Ghana

Bats are considered keystone species because they play a vital role in ecological function – for example, by dispersing seeds or pollination. However, fruit bats, common in the tropics, have been shown to carry viruses which cause fatal, incurable diseases. Although this has been the focus of much research in parts of Asia and Australia, it remains understudied within the African continent. In some regions of Africa, bats are widely hunted for food, increasing the potential for zoonotic disease transmission. Through understanding the ecology of pathogens in their natural hosts, as well as the drivers of zoonotic spillover, our research will inform efforts to prevent disease emergence in people, while also conserving bats.

D British Indian Ocean Territory (BIOT)

Since 2013, the Institute has partnered with the universities of Stanford, Western Australia and Windsor, and the Bertarelli Foundation, to study sharks and rays within the BIOT Marine Protected Area (MPA), using a combination of acoustic and satellite tagging, and DNA and stable isotope analyses. To date, we have deployed tags on and collected tissue samples from 394 sharks and rays across seven species. As a result, we are better understanding the social and spatial ecology of these animals and the important roles they play in the functional connectivity of the ecosystem. In addition, as the MPA is threatened by illegal fishers, we are mapping the spatial interactions between illegal fishing activity and shark movement patterns across the area, in order to inform and shape enforcement and management strategies.

E Mauritius

The Mauritius kestrel (*Falco punctatus*) is one of the greatest conservation success stories, recovering from just four birds in Black River Gorges in 1974 to over 350 birds by 2000 in the Black River Gorges and the Bambous Mountains, where it was reintroduced in 1987. Over the past 20 years, in collaboration with the Mauritian Wildlife Foundation and the National Parks and Conservation Service (Government of Mauritius), Institute researchers have been closely involved with the monitoring and management of the kestrel, and have provided scientific evidence to guide the species recovery programme in the long term. The Black River Gorges population is once again in decline (with fewer than 80 kestrels), and our research is determining the drivers of this decline and identifying remedial management actions, including reintroductions into unoccupied habitat outside Black River Gorges and the development of conservation management plans.

F Indonesia

Tropical peatlands are globally significant carbon sinks as well as biodiversity hotspots. Peat consists of incompletely decomposed plant material that has accumulated over thousands of years in waterlogged, oxygen-poor environments, and peatlands can store huge amounts of CO₂. The natural vegetation in such habitats is peat-swamp forest, much of which is being cleared and replaced by plantations. There are many species specialists that depend on peat-swamp forests, such as freshwater fish and certain trees. In addition, the release of large quantities of CO₂ into the atmosphere through forest clearance, peat drainage and fires is threatening species worldwide through the effects of global warming. We are mapping the loss of peat-swamp forest in Sumatra using state-of-the-art methods and freely available remote-sensing data in order to support conservation and restoration efforts in the region.



To find out more about our current research projects, visit zsl.org/science/research

Institute of Zoology news

Over the past year, researchers at the Institute have been recognised for achievements in conservation science – as well as for standing up for science in general.



▲ Marsh Award for Ornithology

Congratulations are due to Senior Research Fellow Becki Lawson, who has been awarded the prestigious Marsh Award for Ornithology by the British Trust for Ornithology (BTO) in recognition of her work on disease effects on free-ranging wildlife populations. Becki has been instrumental in highlighting the issue of trichomonosis in British finches, an emerging disease that has resulted in the decline of the British greenfinch population by over a third. She has also worked on avian pox in British tit species and on diseases in other garden wildlife, including hedgehogs, amphibians and snakes. Becki leads the Garden Wildlife Health project (see also page 14), a citizen science initiative launched in 2013, which investigates the health status of Britain's garden species through the support of the general public.



▲ Athena SWAN Bronze Award

In July, the Institute received an Athena SWAN Bronze Award in recognition of our ongoing commitment to the advancement of gender equality, representation, progression and success for all. We have an international reputation for excellence in conservation science, but we also want to be known for the quality of the working environment we offer to scientists throughout their careers. We believe that excellence in our science is underpinned by diversity among our scientists, and we want to create a more inclusive, flexible and supportive working environment that promotes and retains this diversity. In so doing, we believe we will be creating a higher-quality working environment – for everyone.

▲ Standing up for science

Senior Research Fellow Rosie Woodroffe was commended for the 2017 John Maddox Prize for Standing up for Science, for her work championing a scientifically based approach to the control of bovine TB in relation to badgers. The prize recognises the work of individuals who promote sound science and evidence on a matter of public interest, facing difficulty or hostility in doing so. Rosie's work highlights the risks of trying to control cattle TB by culling badgers, because changes in the behaviour of the surviving badgers can increase disease spread, rather than curtailing it. This is the first time the prize has recognised work relating to the natural environment.



Top: Stephanie Jayson (left) and Helle Hydeskov (right) at graduation.

Below left: our much-missed colleague Ben Collen, pictured with Sir David Attenborough. Below right: the 'Where the wild things are' team in action

Keep up to date with all the latest
Institute news at zsl.org/science/news



▲ Master of Veterinary Medicine graduations

Stephanie Jayson and Helle Hydeskov successfully graduated with a master's degree in Veterinary Medicine from the Royal Veterinary College in July 2018. This qualification is an outcome of their senior clinical training scholarships, co-run by ZSL and the Royal Veterinary College. These training programmes focus on Wildlife Population Health and Zoo Health Management, under the governance of the European College of Zoological Medicine. ZSL staff provide a range of teaching in Wildlife Health to veterinarians, from undergraduate placements and postgraduate degrees, such as the MSc in Wild Animal Health, to PhDs and these three-year residency programmes.

▼ Remembering Ben Collen

It is with great sadness that we pay tribute to our friend and colleague, Ben Collen, who died in May at the age of 40 following a bone-cancer diagnosis just 15 months earlier. After completing his PhD at the Institute and Imperial College London in 2005, Ben joined ZSL as a postdoctoral research associate, later heading up our Indicators and Assessments Unit. Ben developed the conceptual and analytical basis for the Living Planet Index, the comprehensive data set that informs the

WWF *Living Planet Report*. The report is now a staple of the environmental calendar, widely accepted as a trusted barometer of the state of life on our planet. In 2013 Ben became a lecturer then reader in biodiversity at UCL's Centre for Biodiversity and Environment Research, but his connection to ZSL continued through his research and supervision of numerous PhD and MSc students. Ben had a gift for science, and a gift for friendship, and he will be sorely missed.



▲ Wild Science Podcast

Delve into topical issues in zoology, conservation and the environment with our ZSL Wild Science Podcast. Hosted by Institute researcher Monika Böhm, our podcast offers engaging discussion and insight on the science being done to advance conservation work around the world. Subscribe via iTunes, Spotify or any podcast app, or visit zsl.org/zsl-wild-science-podcast to listen to episodes.



▲ Royal Society Summer Science Exhibition

The Royal Society Summer Science Exhibition is a week-long festival celebrating the most exciting cutting-edge science and technology in the UK. The ZSL stand 'Where the wild things are' was one of 22 exhibitors at this year's event. Twelve thousand visitors, including public and school audiences, had an opportunity to hear how our researchers develop and use novel technologies, such as adapted cameras, tracking devices and camera traps, to monitor and understand the status and behaviour of animals around the world.

Science for conservation

Director of Science Ken Norris outlines our exciting plans for a new focus on tackling wildlife disease and improving animal health, including a world-class science campus at ZSL.



Over the past few months, ZSL's Directors have been working hard to develop our new strategy – ZSL 200. This sets out our vision for ZSL's 200th anniversary and beyond, including the priorities and major projects that will shape our third century as an organisation.

One of our ambitions is to transform the science we are able to do by creating a Science for Conservation Campus at Regent's Park. Why are we doing this, and what will it involve?



The Institute of Zoology's research staff have a distinctive combination of expertise from veterinary and biological sciences. This has enabled our research to take novel and innovative approaches to wildlife conservation, including exploring transboundary issues between the health of wildlife, domestic animals and people. Understanding wildlife health is key to successful wildlife conservation outcomes. Our science has played

a leading role in helping to understand the impacts of infectious disease, environmental pollutants and other environmental stressors on wildlife populations and communities. For example, our work showing that global amphibian declines are driven by a fungal pathogen was described in *Nature* (394, 418-419) as 'an exemplary example of international scientific collaboration'.

We recognise that wildlife conservation and its associated drivers have close links with the health of domestic animals, as well as the health and wellbeing of people (often termed 'One Health'). Wildlife is a key, but poorly understood, component of disease pathways affecting animal and human health. Most newly emerging, globally significant human infectious diseases originate in wild animals (including Nipah, SARS, Ebola, Zika and MERS), and the rate of disease emergence is accelerating. There is growing evidence that human connections with wildlife can have a positive impact on mental health and other social outcomes (for example, youth truancy



and crime), and wildlife is part of multiple pathways linking the environment with human health and wellbeing (such as food security and sustainable development). Our ambition is to transform the ability of the national and international research base to address these issues. The new campus will provide the facilities to help us do this.

We plan to create the campus in collaboration with University College London (UCL) and the Royal Veterinary College (RVC). The global challenges we aim to address require new ways of working, and we need to give people the skills they need to do this. We plan to:

- Develop a centre of research excellence in One Health, with a core focus on wildlife health and conservation science;
- Create a unique training environment for students and professionals that helps people develop new skills, enabling them to work at the interface between wildlife, domestic animal and human health;
- Accelerate the translation of research into use to maximise impact; and
- Provide a national and international focus for public engagement activities.

At the heart of our ambitions are people. We want to inform, inspire and empower people to address the global challenges we face in wildlife conservation and human health. We will need significant funding, as well as support from all our staff, students, friends, supporters and collaborators. We are all very much looking forward to this journey!

Impact Areas

In the pages that follow, we highlight a selection of Impact Areas where our research is making a difference. From historical extinctions, fostering coexistence between people and wildlife, and long-term studies for species recovery programmes to garden wildlife health, amphibian disease and predictive ecology, our work is continually advancing conservation science.



Threatened
species recovery
and our long-
term studies
10



Predictive
ecology
12



Investigating
emerging threats
to garden
wildlife health
14



Lessons from
the past: historical
baselines
in conservation
16



Fostering
coexistence
between people
and nature
18



Amphibian
infections on
the move
20

Threatened species recovery and our long-term studies

Bringing the world's most threatened species back from the brink of extinction requires long-term commitment in order to inform evidence-based conservation management. Here, we highlight examples of the Institute's long-term programmes for species recovery.

Recovering small populations of the world's most threatened species is a substantial challenge; one that requires long-term commitment and strategic use of science to inform our management choices. The challenge is made ever more difficult by the uncertainties around the causes of rarity and the effectiveness of management to support recovery. Even if we know what is going wrong, we may not know how best to overcome it. Threatened species recovery takes time, so the application of science and strategic monitoring of conservation interventions should equally be viewed in the long term.

Our work strives to link conservation science and management. Multiple

Institute projects have been running for many years, and have contributed to evidence-based decisions throughout a species' often-difficult journey of recovery.

These projects include bird species such as New Zealand's hihi (*Notiomystis cincta*)

(for which we hold 26 years of demographic data); the Mauritius kestrel (*Falco punctatus*) (over 30 years of data) and the Mauritius parakeet (*Psittacula eques*) (26 years of data), as well as mammal species such as the cheetah (*Acinonyx jubatus*) (27 years of data) and African wild dog (*Lycaon pictus*) (17 years of data). Our work in New Zealand has carefully evaluated how best to support reintroduced populations of hihi with supplementary feeding (for example, Chauvenet et al. 2012). Our work in Mauritius has evaluated the costs and benefits to kestrels from egg harvesting to increase productivity (for example, Nicoll et al. 2006), and our work across the cheetah's global range has evaluated the role of protected areas in reducing extinction risk (Durant et al. 2017). In addition,



our scientists take lessons from these, and other similar projects, to provide overarching advice to other recovery programmes globally (for example, Crees et al. 2016; Taylor et al. 2017). Research on our long-term projects has produced a range of valuable outputs over the past year. These have predominantly focused on island species.

Post-release effects in reintroduction

Reintroduction is an increasingly common management tool in conservation. However, translocated animals often suffer a period of elevated mortality after release. These effects should be accounted for when post-release monitoring data are interpreted and management recommendations made for population persistence. Failing to do so can result in incorrect conclusions about release-site suitability, or inaccurate projections of post-release population growth. Armstrong et al. (2017) developed a flexible method where the acclimation period over which post-release effects occur is treated as unknown, and is estimated simultaneously with the pre- and post-acclimation survival probabilities. This method was developed using long-term survival data for reintroduced populations of three New Zealand forest bird species, including the hihi. Post-release effects occurred in five of six reintroduced populations, ranged between one and nine months in duration, and caused 30-84% of mortality during this time.

Conservation management of the Mauritius parakeet

The Mauritius parakeet was once considered the rarest parrot in the world. Nearly 25 years after intensive recovery efforts for the species were initiated, its conservation is entering a new phase that looks towards a long-term strategy of minimal management. Achieving this requires a basic knowledge of the population's demography, and an assessment of the demographic response to management actions and infectious disease. Gath (2018) worked extensively with the

long-term demographic data to determine the role of supplementary feeding in supporting population recovery (through improved fecundity), and its interaction with beak and feather disease virus emergence, which had a disproportional effect on the breeding success of fed birds.

Species Conservation: Lessons from Islands

Our work with the hihi, Mauritius parakeet and other long-term studies has contributed to a recent book, *Species Conservation: Lessons from Islands*, published by Cambridge University Press (Copsey et al. 2018). The book contains chapters by six past and current Institute staff and students on understanding the ecological (Young et al. 2018) and genetic (Groombridge et al. 2018) histories of threatened species, as well as the roles of both ecology and genetics in managing recovery, along with a structure for best evaluating these, and other, possible management solutions (Jones et al. 2018).

Future research

Our long-term studies support threatened species recovery and are, naturally, very applied. The impact of our science programmes is therefore reflected in evidence-based management decisions and changes to management following analysis of monitoring data. Ultimately, our measure of success within each project is species recovery, and the success of the island bird programmes included here show we have reason to celebrate. New Zealand hihi populations have grown from one to seven through reintroduction; the Mauritius parakeet has recovered from only a few individuals to 136 adult breeding pairs through intensive management. A key part of our approach is to develop capacity, and we are involved with various initiatives to train conservation practitioners in how best to use science to inform management. Going forward, this will make our reach far greater than simply helping the immediate species with which we work.

Top left: Helen Gath's research is helping us better understand how to support the recovery of the Mauritius parakeet. **Top right and inset, far left:** our scientists have

been supporting the reintroduction of the hihi, a New Zealand forest bird. **Below left:** the African wild dog is another focus of ZSL's long-term research work



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Predictive ecology

The availability of large-scale ecological and behavioural data sets provides new opportunities for analysis, modelling and extrapolation. From identification of individual animals and behaviours in acoustic and imagery data to understanding the impact of future environmental change, these techniques present new insights for conservation science.

Our ability to monitor the natural world is changing rapidly. Newly available tools that record large volumes of imagery, acoustic or behavioural data are supporting novel analyses on the status and trends of animals, habitats and ecosystems. These data provide a growing opportunity to construct ecological and behavioural models to understand large-scale patterns and processes and to use these models to extrapolate in space and time. The Institute's research in this field has grown rapidly: we are applying new machine-learning techniques to identify species and monitor habitats, classifying and monitoring behaviour, and demonstrating how predictive ecology can be used to extrapolate the future impacts to global wildlife.

Predicting the impact of environmental change

As our environment continues to change, and wildlife and ecosystems face increasing challenges, predictive models can help us to understand how future environmental change may impact species and their habitats. For example, Lee et al. (2018) presented a new methodology to use remotely sensed data to assess the vulnerability of ecosystems to climate change.

We have also used predictive classification to identify mangrove habitats in combination with reconstructed sea-level-rise data, to determine that many mangrove ecosystems are highly vulnerable to sea-level rise (Duncan et al. 2018). Our research also shows that populations of birds and mammals appear to be declining faster in areas of the world where warming has been most rapid (Spooner et al. 2018). Extrapolating this under worst-case climate scenarios would suggest severe annual declines of 3.85-4.65% in bird populations.

Our research also aims to understand how the future climate may impact biodiversity globally; for example, Foden et al. (2018) present a new framework for identifying hotspots of climate-change risk for mammals (also see Pacifici et al. 2018 for a review). Understanding how land-use change may impact biodiversity is the focus

of a new collaboration with the International Institute for Applied Systems Analysis, to understand how conservation status and wildlife abundance may change under different future land-use and climate scenarios (Leclere et al. 2018).

Identifying species

Our research has begun to explore how acoustic data can be used to identify and monitor species. Mac Aodha et al. (2018) used deep learning to train a classification system to



automatically identify bat species from acoustic recordings. Such deep-learning approaches are particularly interesting, as they can automate the often-complex process of finding which data features to use in prediction. This technique is now being explored across a variety of our projects using new low-cost audio recorders. Such approaches are not limited to data from acoustic recorders, and we are now using these techniques to predictively identify species from camera trap images.

Predicting the conservation status of data-deficient species

In addition to predicting the presence or absence of species from images or acoustic data, these techniques can be used to map our understanding of extinction risk onto lesser-studied species. Bland et al. (2016) used machine learning to identify which

data-deficient reptiles were likely to be at higher risk of extinction. This approach uses the growing number of species assessments to understand those features that make a species more likely to be at risk of extinction.

Predicting behaviour

With the advent of new bio-logging and telemetry devices, such predictive techniques are also applicable to the behaviour of individual animals and groups. Browning et al. (2018) used deep learning to predict when diving seabirds were engaged in foraging underwater. Using a large collaborative data set of combined GPS tracking and dive logging, they demonstrated that it was possible to predict diving behaviour using just easily obtainable and lower-cost GPS data. Such approaches may allow historical data sets to be combined to identify sea locations that are critical for seabird foraging.

Williams et al. (2018) used four years of acoustic telemetry data from grey reef sharks (*Carcharhinus amblyrhynchos*) to predict movement patterns within the monitored populations. This research demonstrated that the shark's movements were critical in bringing high quantities of nutrients back to the reefs that they inhabit, suggesting a significant role in facilitating the primary productivity of the ecosystem (see also page 24).

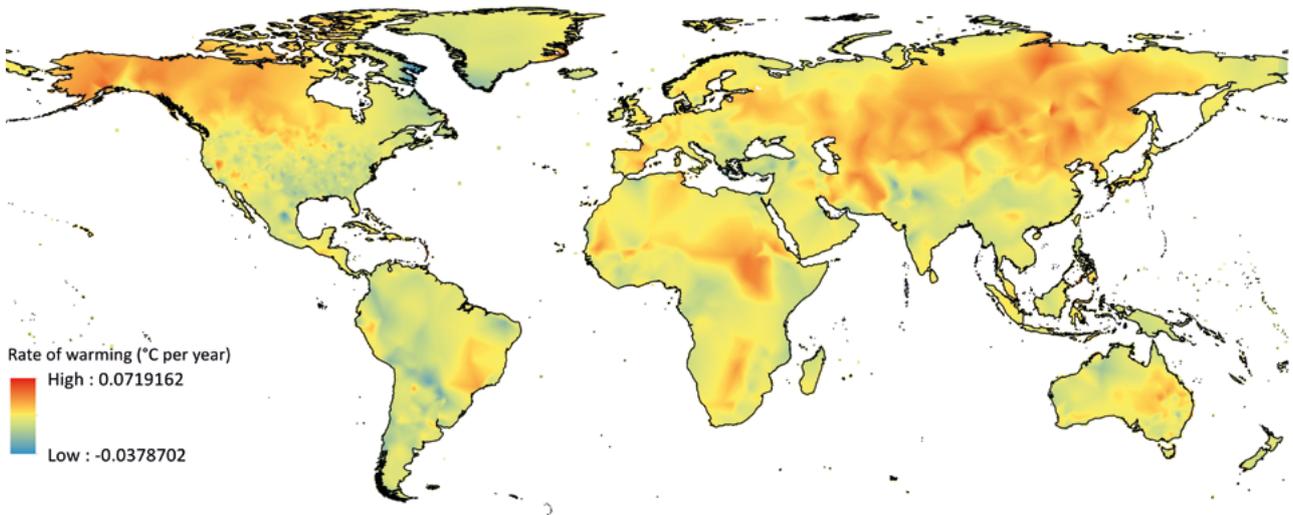
Future research

As these conservation and ecology data sets continue to develop, the opportunities to use these data in combination with cutting-edge machine-learning and pattern-recognition tools are also growing. However, the richness of these data and our development of new analytical tools may also provide new insights about how best to manage and conserve our natural world. To facilitate this, as part of our partnership with the Quantitative and Modelling Skills in Ecology and Evolution (QMEE) Centre for Doctoral Training at Imperial College, the Institute welcomes three new PhD students starting in October 2018, with a focus on the application of machine learning in conservation and ecology.

Far left: our acoustic recorders can provide valuable data on species such as bats. Top right: Institute research has predicted which regions of the planet

will experience higher impacts from environmental change than others. Bottom of page: we have used predictive classification to understand how

the rise in sea levels impacts mangrove ecosystems such as this one, and have found that these areas are extremely vulnerable



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Investigating emerging threats to garden wildlife health

Institute researchers monitor the health of, and identify disease threats to, British wildlife. We reveal the impact of Garden Wildlife Health, a citizen science project that we run in partnership with the British Trust for Ornithology, Froglife and the RSPB.

As a result of ongoing land-use change and urbanisation, garden habitats are an increasingly important refuge for many species of native wildlife, with private gardens estimated to provide over 430,000 hectares of potential habitat across Great Britain. Gardens also offer an opportunity for people to develop an interest in wild animal welfare and conservation, helping to address a growing disconnect between people and nature associated with detrimental effects on human health and wellbeing. There has been mounting enthusiasm for wildlife-friendly gardening in recent decades, alongside awareness that the way in which we manage garden habitats can influence the health and welfare of the wild animals that use them. Unfortunately, there are an increasing number of examples where wildlife disease has led to population declines of British species. Some conditions in wild animals can also cause ill health in people, pets and livestock. By monitoring wildlife health, we aim to improve our understanding of wildlife diseases and identify ways to mitigate them.

Disease surveillance for garden wildlife

In partnership with multiple organisations, we have championed the use of citizen science – where members of the public become part of the team involved in the investigation – for garden wildlife disease surveillance in Great Britain since the early 1990s. We initially focused on amphibian and garden bird species, using reports of sick and dead animals received from members of the public by telephone or letter. This led directly to the discovery of a new disease threat (ranavirosis) to amphibians in Great Britain.

In 2005, a partnership with the British Trust for Ornithology’s Garden BirdWatch scheme enabled systematic surveillance to be conducted for the first time. A network of participants provided reports every week across Great Britain, stating whether or not they saw evidence of health problems in garden birds. This allowed for us to control

reporting bias and to analyse the true scale of disease occurrence, its seasonality and its distribution across the country. Crucially, it also allowed us to integrate the monitoring of wildlife abundance with disease-surveillance data, enabling quantification of the impact of wildlife disease at a population level, and helping to determine if it may be of conservation concern. In 2013, the current project, Garden Wildlife Health (GWH), was launched, moving our disease-surveillance system online, with the public now reporting incidents via our website (gardenwildlifehealth.org).

In addition to bird health, we also monitor conditions affecting wild hedgehogs (*Erinaceus europaeus*) and reptiles. Hedgehog populations have declined in recent decades and there is a need to investigate whether disease may be contributing to this trend; while, of all vertebrate taxa, we know least about the health of terrestrial reptiles, so our goal is to address this knowledge gap. Post-mortem examinations are carried out at the Institute to identify the cause of death and any potentially important underlying conditions, and to collect samples for further study. As a result of this work, the Institute houses the largest wildlife-tissue archive in the country, supported by data from over 4,500 pathological investigations, a unique and valuable resource for the future.

Impact of our Garden Wildlife Health research

Garden bird feeding is practised year-round in Great Britain and is probably one of the largest-scale interventions the British public make with native wildlife. While there are benefits of providing supplementary food to wild birds, feeding can also increase the risk of disease outbreaks by creating opportunities for pathogen transmission. We collated 25 years of our garden bird disease-surveillance results, focusing on two emerging infectious diseases – one parasitic (finch trichomonosis), one viral (Paridae pox) – as well as a third, endemic bacterial disease (passerine salmonellosis). We then identified risk factors

for disease transmission, for example: poor hygiene at feeding stations, high densities of birds feeding together for prolonged periods, and mixing of species in close proximity that would not naturally occur in the wild (Lawson et al. 2018). This research enabled us to offer best-practice guidance for disease prevention and control in garden birds, and to share this through disease factsheets on our website, media interviews, conference presentations and other outreach events.

To maximise the impact of our research, we convene a biannual Garden Wildlife Health forum at the Institute to share recent findings with conservation and animal welfare non-governmental organisations, pet trade and wild bird food companies, academia, wildlife gardening organisations, wildlife rehabilitation centres and Government. Being based at ZSL London Zoo, we also have the opportunity to communicate our findings to Zoo visitors in ZSL’s Wildlife Garden. We also form part of the Government’s GB Wildlife Disease Surveillance Partnership, which offers a route to share our findings with policymakers and national animal and public health agencies.

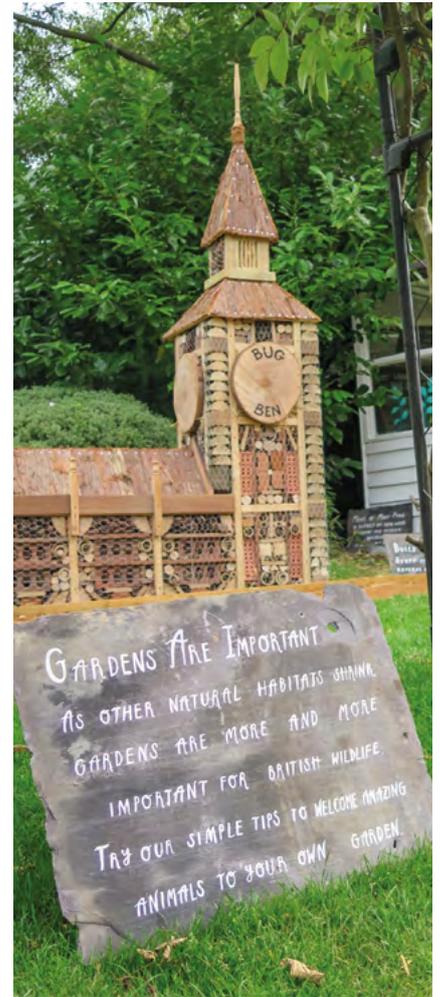
Priorities for the future

Our research will continue to improve our understanding of recently detected emerging conditions, such as snake fungal disease (Franklinos et al. 2017), and to provide early-warning systems for new threats such as *Batrachochytrium salamandrivorans*, a fungus causing epidemic mortality in wild salamanders across continental Europe, but not yet known to occur in wild amphibians in Great Britain. There is an urgent need to develop disease-response and management plans, and to raise awareness to help prevent pathogen incursion through trade and movement of captive amphibians. Moving forward, we need to find ways to continue to expand and optimise wildlife disease surveillance by connecting with new communities – for example, developing stronger links with ecological consultants and licensed bird ringers.

Top left and centre left: bullfinches (*Pyrrhula pyrrhula*) and greenfinches (*Carduelis chloris*) are two of the wild bird species that benefit from garden feeding, but also

risk disease transmission at feeding stations. Bottom left: our Garden Wildlife Health research also encompasses reptiles such as the grass snake (*Natrix natrix*). Top right:

the Wildlife Garden at ZSL London Zoo engages the public with our work. Bottom right: championing the Garden Wildlife Health project at Gardeners' World Live



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Lessons from the past: historical baselines in conservation

Institute research on historical extinctions is improving our understanding of past human impacts on global biodiversity and is informing environmental restoration and conservation planning.

Evidence-based conservation of threatened species or ecosystems requires the use of robust data on key biological and environmental parameters to inform management. Most data used in evidence-based conservation come from modern-day ecological studies, which typically represent a very recent snapshot of environmental conditions – it’s estimated that only 15% of so-called long-term ecological studies use data sets spanning more than a century. However, humans have modified biodiversity by causing population and species extinctions, moving plants and animals around the globe, and altering ecosystem structure and function, far back into prehistory. Some form of human association with the extinction of much of the world’s mammalian megafauna between 46,000 and 11,700 years ago during the Late Pleistocene is now widely accepted by most palaeontologists, and human involvement in nearly all extinctions and many ecosystem changes during the subsequent Holocene Epoch is relatively undisputed.

Conservation palaeobiology

Without the insights provided by long-term environmental archives, we are unable to determine the true magnitude of human impacts on global biodiversity. As a result, our understanding of the key properties of biodiversity, such as the structure, composition, and function of ecosystems in the absence of human modification, and former distributions of threatened species now restricted to suboptimal habitat fragments, will remain both incomplete and biased by an ‘extinction filter’ if only assessed using modern-day data. There is growing awareness of the need for a new discipline of ‘conservation palaeobiology’ in order to identify past environmental baselines and reconstruct both extinction dynamics and ecosystem properties in ways that we cannot achieve using short-term studies.

Novel insights on extinct species

Institute research on environmental archives from around the world has led to ongoing

discoveries of recently extinct species and genera from archaeological or subfossil remains. These discoveries improve our understanding of the magnitude of human-caused biodiversity loss through time and allow us to identify geographical regions and taxonomic groups that have been impacted heavily by human activities. Recent descriptions of extinct vertebrates in Holocene deposits from tropical Caribbean and Indonesian islands, including rice rats *Antillomys rayi*, *Megalomys georginae* and *Pennatomys nivalis* from the Lesser Antilles (Brace et al. 2015), giant rodents *Raksasamys tikusbesar* and *Milimonggamys juliae* from Sumba (Turvey et al. 2017a), and the giant tortoise *Chelonoidis marcanoi* from Hispaniola (Turvey et al. 2017b) highlight the vulnerability of island faunas, and show that many of today’s island systems are now drastically modified and have lost key components of biodiversity that likely contributed to wider ecosystem functioning. Similarly, the discovery of new genera of recently extinct primates, such as *Insulacebus toussaintiana*, a monkey from Haiti (Cooke et al. 2011), and *Junzi imperialis*, a gibbon from China (Turvey et al. 2018), challenges the assumption that, although primates are disproportionately threatened today, they have not experienced elevated levels of past extinction. Past human-caused loss of primate diversity may be underestimated, with important implications for understanding extinction vulnerability.

Institute research into past environmental baselines and long-term species declines has also challenged how we can define ‘native species’ (Crees and Turvey, 2015), and provided new insights into spatial patterns in the dynamic biogeography of extinction events. Multi-century historical gazetteer records, museum skins and animal bones in archaeological middens have revealed that past population losses for many mammals in China (including gibbons and Père David’s deer (*Elaphurus davidianus*)) show a ‘contagion’ model of range collapse in response to the directional demographic expansion of human pressures across eastern Asia (see Turvey et al. 2015). Populations of these species survived longest

in areas along the edge of their ranges that were impacted last by extinction forces, rather than near the centre, where populations might have been larger (Turvey et al. 2015, 2016, 2017c). Analysis of large-scale data sets for the Holocene mammal faunas of China and Europe has also revealed that the timing, duration and magnitude of population declines vary individually between species, and that both phylogenetic and spatial patterns of extinction selectivity have varied over time, probably in response to a combination of cumulative anthropogenic impacts and quantitative and qualitative changes in human activities (Turvey et al. 2017d).

Informing conservation policy

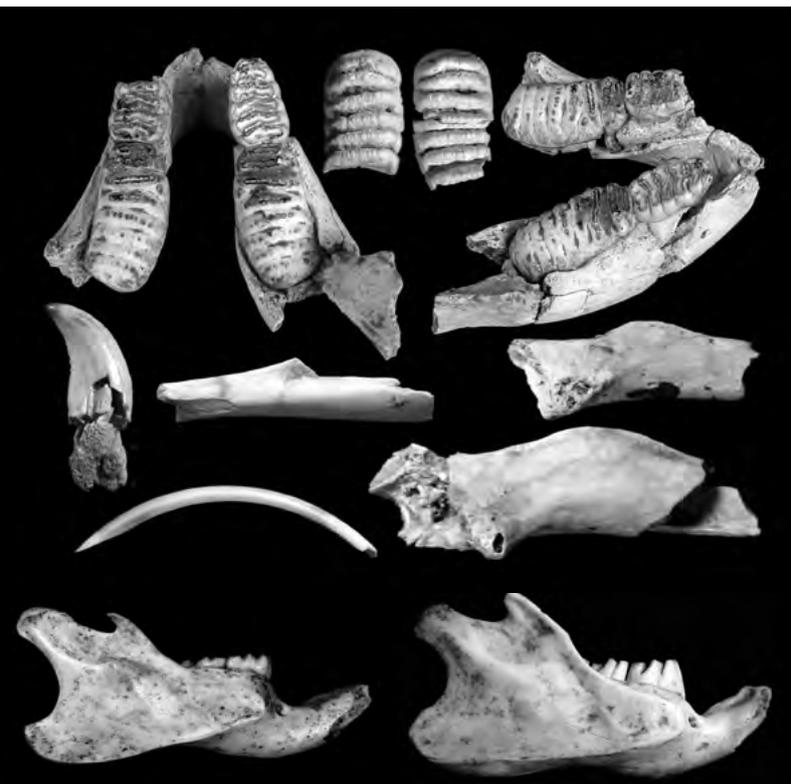
Data from long-term archives can be used to make predictive hypotheses about extinction vulnerability and resilience and are increasingly used to inform conservation policy and provide management goals for restoring locally vanished species and rewilding historically disrupted ecosystems. Many avenues for using historical baseline data are still underutilised, such as the incorporation of past species distribution data into habitat-suitability models to identify priority conservation landscapes and predict likely responses to future climate change.

Our research into conservation palaeobiology also raises important and challenging questions. If faunas have shown ongoing change in response to human activities through time, how do we best identify static past baselines to inform current-day environmental restoration, and define what constitutes a ‘natural’ ecosystem? If selectivity of human-caused extinctions has changed through time, how exactly can we use long-term archives for environmental forecasting, or modern-day data to predict future extinction patterns? And what environmental archives are even available for biodiversity hotspot areas in the tropics, where conservation interventions are most urgent? Our ongoing work on the scope and application of historical baselines is addressing these key questions, to determine how best to integrate long-term archives into modern conservation planning.

Top: our research has shed new light on the long-term decline of Père David's deer, now Extinct in the Wild.

Below: examining museum specimens and animal

bones found in archaeological middens has provided novel insights into historical extinctions



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Fostering coexistence between people and nature

Institute researchers are showing how inter-disciplinary science can advance our understanding of the complex relationships between wildlife and people and inform strategies to foster coexistence. Here are a few examples of our work.

Sustainable development can only be achieved if it does not destroy the ecosystems on which people and wildlife depend. Yet rising population and consumption will place unprecedented pressure on the planet's support systems. Institute research is addressing these issues.

Exploring ecosystem limits to poverty alleviation

In Africa, agriculture is a major pathway out of poverty. As well as generating a secure supply of food, farming also provides a way of growing cash crops that can generate income. Improved incomes can in turn improve education, health and a range of other social outcomes or dimensions of poverty, as they are sometimes termed.

Farming often takes place on land converted from natural habitat, such as tropical forest. If the farmland is subsequently well managed, it can be productive for decades. If it isn't, productivity can deteriorate, and new areas of forest or other habitat, if they are available, have to be cleared. This process threatens forests and their biodiversity, as well as the lives and livelihoods of farming communities. Safeguarding forest and managing farmland to maximise production are, therefore, two sides of the same coin.

We set out to examine these inter-relationships in a project in Ghana and Ethiopia funded by the Ecosystem Services for Poverty Alleviation (ESPA) programme. Both study locations consist of a large area of intact forest surrounded by a forest-agriculture landscape growing important cash crops – cocoa (Ghana) and coffee (Ethiopia). We found novel relationships between forest cover and agricultural productivity; for example, cocoa farms have higher yields when close to intact

forest, and yields decline with distance to intact forest. By defining limits to agricultural production, we identified significant scope for yields and livelihoods to be improved through measures that are relatively simple to implement. Our research showed that improved yields could alleviate poverty in certain dimensions, but that other dimensions of poverty were insensitive to agricultural improvement. Understanding these relationships is essential if we are to identify pathways out of poverty that are sustainable in terms of ecosystem limits.

Environmental strategies for food production in the UK

Intensive agriculture is needed to meet the needs of the world's increasing population, but it comes at a high cost: there are heavy trade-offs between food production and the environment. Agriculture is a leading cause of biodiversity loss, and it has many negative impacts, such as degradation of soil and water quality. Farmers are increasingly reliant on inputs, such as fertilisers and pesticides, to replace services once provided by nature. This situation is unsustainable; intensive farming systems will need to change if they are to keep producing enough food for our growing population while also avoiding environmental degradation. Our research tries to reconcile these conflicts.

In the UK, the weed black grass (*Alopecurus myosuroides*) is now resistant to nearly all herbicides, leading to problems for farmers growing winter wheat, the country's main crop. Our research aims to understand the economic, food production and environmental impacts of black grass, and to develop non-chemical ways to control the weed. We assess the impact of each potential strategy to identify the one that

can produce enough food, be profitable and benefit the environment. We model farmland bird populations, carbon emissions and nitrate leaching to try to ensure improvements in multiple environmental parameters. In England, black grass causes significant loss of wheat yield annually, which may result in higher food prices and the need to increase imports. We aim to provide farmers and policymakers with environmentally sound strategies to mitigate problems with resistant weeds.

Reinforcing the case for rewilding

Rewilding is a rapidly developing concept in ecosystem management, representing a transformative approach to conserving biodiversity. Originally defined as a conservation method based on 'cores, corridors and carnivores', the term is now broadly understood as the repair or refurbishment of an ecosystem's functionality through the (re)introduction of selected species. Rewilding has the potential to represent a cost-effective solution to enhance local biodiversity and ecological resilience, reinstate vegetation succession, reactivate top-down trophic interactions and predation processes, and improve ecosystem service delivery. As such, it has become increasingly fashionable among conservation commentators and policymakers.

Despite its growing popularity, however, there are uncertainties associated with the implementation of rewilding, with the evidence available for facilitating sound decision-making for rewilding initiatives remaining elusive. To address this issue, we identified priority areas where scientific research has potential to reinforce the case for rewilding (Pettorelli et al. 2018). These include setting better-informed targets for the recovery of ecosystems; accepting some level of risk due to the inherent unpredictability of ecological outcomes; realistically evaluating costs and benefits; and understanding the potential social impacts of rewilding initiatives. Finally, the study's authors are calling for long-term, practical and scientifically sound monitoring of these projects to ensure progress against goals.



Inset, far left: growing cash crops, such as cocoa, can improve the livelihoods of farmers in Ghana.

Bottom left: the weed black grass is now resistant to

nearly all herbicides. **Bottom right:** resistance assays are being employed to investigate non-chemical ways of controlling black grass. **Top right:** could rewilding

see species such as the Eurasian lynx (*Lynx lynx*) reintroduced to their former territories?



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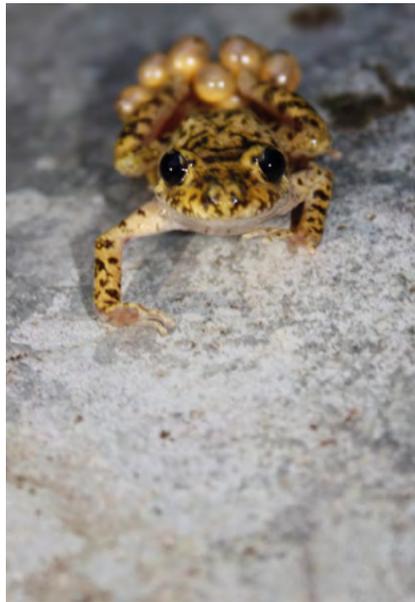
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Amphibian infections on the move



Amphibian populations are at grave risk from two deadly groups of pathogens – chytrid fungi and ranaviruses. Institute researchers are exploring how these diseases are transmitted to inform amphibian conservation across the globe.

Nearly three decades of research at the Institute has been invested in proving how two amphibian parasite groups, ranaviruses and chytridiomycete fungi, cause the diseases most commonly associated with global amphibian declines. We have witnessed first-hand the consequences when these pathogens relocate to previously unaffected amphibian populations, and are working towards reducing the likelihood of new emergences, as well as controlling what happens when disease outbreaks occur. To do this requires an understanding of the pathways and processes that allow pathogens to access areas and hosts not previously available to them. We have used the results of numerous studies of the spatial and host distribution of infections, molecular studies of pathogen genomes and experimental assessments of host susceptibility and behaviour when confronted with the risk of infection to show how amphibian infections may move.



The global pet trade in amphibians

Perhaps not surprisingly, infections are often moved by the amphibians themselves: not all amphibians succumb to disease, despite being infected, or they may carry infections into new locations before experiencing potentially lethal disease. What might be surprising is how these amphibians move, or rather, are moved. Enormous numbers of frogs, toads, newts, salamanders and caecilians are transported outside of their native ranges by humans for various economic purposes. For example, thousands of amphibians are imported annually to the UK by the pet trade from the Americas, Asia, Africa and continental Europe. A significant number of these animals are infected with chytridiomycete fungi (Cunningham et al. 2015; Wombwell et al. 2016). By sequencing the genomes of fungal isolates from across the globe, we and our collaborators have shown that this is a worldwide problem, and that the likely source of all amphibian-infecting chytridiomycete fungi lies somewhere in Asia (Martel et al. 2014; O’Hanlon et al. 2018).

Chytridiomycosis might not be the global conservation problem that it is if imported animals did not come into contact with native amphibians. In collaboration with researchers in France, we have shown how the infections carried by invasive species can cause lethal disease in native species (Miaud et al. 2016). Pathogen spillover from invasive sources can then be spread by native hosts, but regional spread still involves human activities. In the UK, genomic research has shown that lethal ranaviruses have been introduced multiple times. Although a significant proportion of the current distribution of lethal disease might be consistent with amphibian dispersal, ranaviruses are also spread through translocations by humans between garden ponds (Price et al. 2016; Price et al. 2017).

Understanding patterns of disease

Pathogen invasions into native, wild amphibian communities can infect one, a few, or all amphibian hosts, resulting in highly divergent disease outcomes. The composition of an amphibian community has a strong impact on whether infections can spread to nearby

locations. In Spain, almost two decades of field data have shown how disease-driven near-extinction of the most susceptible host species has likely limited the spread and impact of disease (Bosch et al. 2018), while in the UK, common frogs (*Rana temporaria*) at ponds with higher temperatures are more likely to become infected and die (Price et al. 2018). The types of habitat an amphibian encounters as it moves among breeding or overwintering sites may significantly modify the number and strength of infections it may carry upon arrival (Daversa et al. 2017). We explored this concept experimentally, using an amphibian species invasive in the UK and postulated to have contributed to the spread of chytridiomycete fungi – the alpine newt (*Ichthyosaura alpestris*). We found that aquatic newts were far more likely to become infected and maintain infections than newts that were kept on land, and that the majority of newts had eliminated infections either before or during overwintering. Interestingly, newts did not discriminate among water that lacked pathogens and water that carried a high risk of infection; however, newts that developed stronger infections reduced their time spent in water. Together, these findings suggest alpine newts can behaviourally reduce risk of disease, and as a result are less likely to spread infections among ponds.

Controlling spread of infection

There is still much to do before we fully understand how amphibians transmit infections while moving from place to place. Certainly, we must continue to explore this topic and use the information to limit the spread of infections that are already present in native amphibians. More immediately, our research provides clear evidence that amphibians in the pet, food and other areas of trade carry potentially dangerous infections and can transmit those if they are exposed to wild amphibian populations. Controlling what we do as humans will be key for reducing the rate at which these, and other, amphibian pathogens spread across landscapes.

Inset, far left: amphibians worldwide, such as this midwife toad (*Alytes muletensis*), have suffered declines due to the spread of deadly chytrid fungi

and ranaviruses. **Top right:** native species such as common toads (*Bufo bufo*) are susceptible to infections spread by the amphibian pet trade. **Below right:** our

work on alpine newts suggests that animals with chytridiomycosis infections spend less time in the water in which they contracted the disease





The impact of our research on amphibian disease

All our research is done through extensive stakeholder engagement: we carry out field trials with local government agencies and wildlife managers in Spain, Italy and Dominica; our protocols and treatments for captive management of infections are embedded in the European Association of Zoos and Aquaria (EAZA) standards for amphibian biosecurity and husbandry; all our field surveillance data sets contribute to global mapping projects; and all genomic, transcriptomic and metabolomic data sets are made available through standard archives.

We have produced molecular diagnostics to identify and quantify infections and have developed methods for isolating pathogens with minimum impact on wild populations. Finally, our relationships with government agencies responsible for the control of animal pathogens and the international scope of our collaborations mean our work informs policy at very large geographical scales; for example, our research on the threat *Batrachochytrium salamandrivorans* poses to European and North American newts and salamanders provided the science behind recent import and trade restrictions of amphibians implemented by the EU, the USA and Canada.

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Our research has tracked the movements of African wild dogs (*Lycaon pictus*)

Our highlights

Alongside our core Impact Areas, our work has encompassed many other areas, from groundbreaking research to educating the next generation of conservation scientists. In the pages that follow, discover some of the highlights from our research studies, education programmes, publications and scientific awards, and meet some of the scientists behind the breakthroughs.



Research highlights
24



How our science is done
28



Education and training
30



ZSL Library and scientific publications
33



Communicating science
34



ZSL Scientific Awards
36

Research highlights

Institute staff and students continue to widen our understanding of the natural world. Here, we present a few of the papers that have been making an impact over the past year.

Analysing Sumatran tiger genetics using scat surveys

Sumatran tigers (*Panthera tigris sumatrae*) are a Critically Endangered carnivore restricted to the island of Sumatra. Like many other large mammals on the Indonesian archipelago, they are threatened by high levels of poaching as well as widespread habitat degradation. We conducted the first range-wide assessment of Sumatran tiger genetics using scat surveys and found that the wild population retains levels of genetic heterozygosity comparable to mainland tigers. However, the population also exhibits signs of subdivision due to the unprecedented rates of deforestation and land conversion in the past 30-40 years. The fact that this subspecies retains such levels of heterozygosity, despite high rates of habitat loss and increasing isolation, suggests a form of genetic extinction debt, with an elevated risk of extinction if no action is taken within the next 30-100 years. However, the inherent

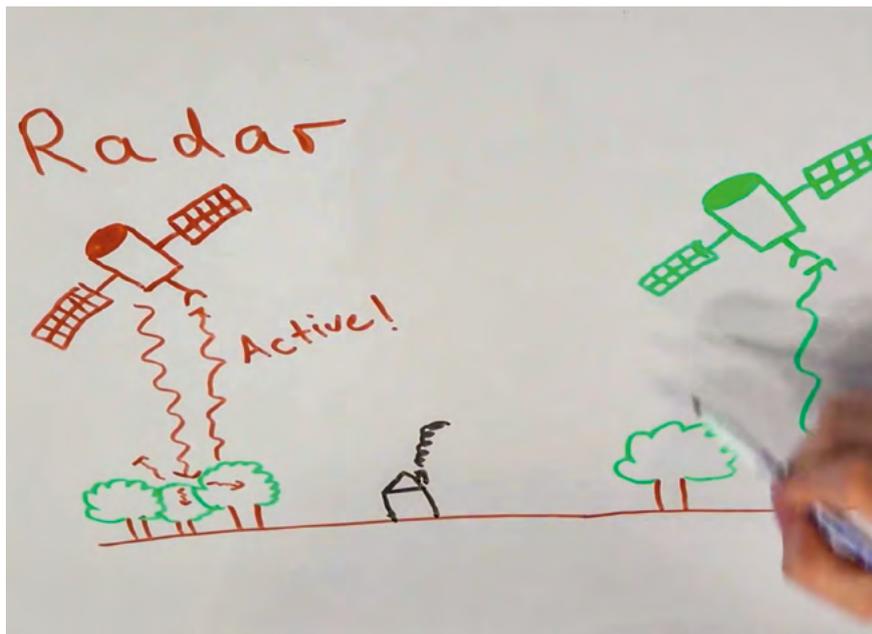


time delay in extinction debt provides opportunities for conservation if habitat quality can be improved and connections between existing population fragments can be made. Our research highlights the importance of genetic studies for providing

baseline information to improve population management of highly threatened carnivore species. Mitigating further habitat degradation and expansion of oil palm and other cash crops in this region would improve the viability not only of Sumatran tiger populations, but also of other threatened large mammal species.

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Smith, O, Wang, J and Carbone, C (2018) Evaluating the effect of forest loss and agricultural expansion on Sumatran tigers from scat surveys. *Biological Conservation* **221**: 270-278



Combining satellite imageries to improve biodiversity observations from space

Over the past few decades, satellite imagery has become an important source of information to track the impacts of global environmental change on wildlife, allowing us to map biodiversity and its threats at large spatial scales. There are currently two main types of satellite imagery – multispectral and radar – which provide global and repeated information about different aspects of the Earth’s surface. Multispectral imagery shows colour and two-dimensional texture, whereas radar imagery shows three-dimensional structure and moisture content. Until now, ecologists and conservation scientists have rarely combined these two types of imagery in their analyses to take advantage of the complementary information they provide. To highlight the opportunities associated with such a combination of information, we reviewed examples in the literature



that used multispectral and radar data in tandem – a process called data fusion – and found that it often increased the accuracy of biodiversity observations. Multispectral-radar data fusion helped map the distribution and structure of ecosystems more precisely than is possible with a single type of satellite imagery, and there are promising signs that it could also benefit species distribution mapping and threat monitoring. As the accessibility and availability of both multispectral and radar satellite imagery continues to grow, we concluded that data fusion has the potential to make significant contributions to improving global biodiversity monitoring capacity in a rapidly changing world.

Reference

Schulte to Bühne, H and Pettorelli, N (2018) Better together: integrating and fusing multispectral and radar satellite imagery to inform biodiversity monitoring, ecological research and conservation science. *Methods in Ecology and Evolution* **9**: 849-865

Far left: an elusive Sumatran tiger is caught on film by a camera trap. Second from left: our video 'Satellite Data Fusion for Ecologists and Conservation

Scientists' helps explain the role of satellite imaging. Top right: research revealed that reef sharks play a key role in ecosystem dynamics. Bottom right: patterns

of aggression in female chacma baboons reflect sophisticated reproductive strategies

Understanding predator movement and nutrient dynamics

The ecological role of reef sharks in coral reef ecosystems continues to attract much debate. This debate revolves predominantly around whether reef sharks occupy apex (top) or mesopredatory (mid-ranking) trophic positions. After all, reef sharks can be a major predator exerting 'top-down' pressure on reef-associated fish communities. Our research shows for the first time that grey reef sharks (*Carcharhinus amblyrhynchos*) also play an important indirect role as nutrient vectors. Extrapolation of data from tagged reef sharks to the population level suggests that reef sharks translocate vast amounts of nitrogen (95kg per day) from their pelagic feeding grounds back to the reef where they reside during daylight hours. Importantly, we were able to quantify these 'bottom-up' nutrient subsidy effects for the whole reef shark population at an un-fished central Pacific Ocean atoll and use network analysis to explore where these nutrients were likely deposited on the reef, showing sex-dependent differences in these patterns based on the different movement strategies of male and female sharks. This paper demonstrates the importance of understanding animal-mediated habitat



connectivity and provides new evidence that reef sharks are fundamental to reef ecosystem dynamics and services.

Reference

Williams, JJ, Papastamatiou, YP, Caselle, JE, Bradley, D and Jacoby, DMP (2018) Mobile marine predators: an understudied source of nutrients to coral reefs in an un-fished atoll. *Proceedings of the Royal Society of London B* **285**: 20172456

Flexibility in female reproductive strategies

Female reproductive rates underpin population growth and viability, but we still have a surprising lack of knowledge about what determines female reproductive strategies at the individual level. The traditional view is that because birth rates are limited by food availability, female strategies primarily reflect competition for food. However, our recent research suggests that female reproductive strategies may be much more complex. We studied patterns of conflict between female chacma baboons (*Papio ursinus*) at our long-term field site in Namibia – the Tsaobis Baboon Project. We were surprised to find that aggression between females was unrelated to food scarcity, and failed to peak among those females experiencing the greatest energetic demands (pregnant and lactating females). Rather, we found that the most common targets of aggression were either sexually receptive females, when conditions in the troops were peaceful; or lactating females, when there was intense male-male competition and a high risk of infanticide (when males kill the offspring of their competitors). Our results suggest that, contrary to the traditional view, female reproductive strategies do not revolve around feeding competition but are highly dynamic and contingent upon the current social context: under peaceful conditions, females primarily compete over mating opportunities, but when there is a risk to offspring, females compete over access to male friends who can protect their infants.

Reference

Baniel, A, Cowlshaw, G and Huchard, E (2018) Context dependence of female reproductive competition in wild chacma baboons. *Animal Behaviour* **139**: 37-49



Identifying hotspots of climate-change risk for mammals

The world has undergone profound climatic changes since the start of the Industrial Revolution, with an average warming of nearly one degree, changes in patterns of rainfall and increased frequency of extreme weather events. All of these changes have had impacts on animal and plant species; however, the extent of these changes has not been systematically analysed until recently, and they may have been greatly underestimated. We reviewed all studies that investigated the presence and kind of impacts (negative or positive) of past

climate change on bird and mammal species globally. We also investigated the ecological characteristics of the species and the locations where the impacted populations occurred, in order to understand what made them more vulnerable or exposed to climate change. We estimated that 47% of terrestrial non-volant threatened mammals (out of 873 species) and 23.4% of threatened birds (out of 1,272 species) may have already been affected by climate change in at least part of their distribution. Mammals most at risk from climate change are non-fossorial species that have experienced large changes in temperature in the past 60 years and have

low precipitation seasonality within their distributional ranges. For birds, negative responses in both breeding and non-breeding areas were generally observed in species that have limited dispersal ability, longer generation time, that live at high altitudes or have low temperature seasonality within their distributions.

Reference

Pacifici, M, Visconti, P, Butchart, SHM, Watson, JEM, Cassola, FM and Rondinini, C (2017) Species' traits influenced their response to recent climate change. *Nature Climate Change* 7: 205-208



Left: climate change is already impacting on many species of birds and mammals, such as the polar bear (*Ursus maritimus*) – and our work is identifying key

risk hotspots. **Right:** reptiles, such as the Australian water dragon (*Intellagama lesueurii*), have traditionally been underrepresented in conservation assessments

Bottom: snares are a threat to wildlife in Cambodia, including Eld's deer (*Rucervus eldii*)

Underrepresentation of reptile species in global biodiversity indicators

Reptiles have often been overlooked in conservation prioritisation in the past, and are not yet adequately represented in global biodiversity indicators that track our progress towards global biodiversity targets. We investigated how reptiles are represented within our Living Planet Database, which underlies the Living Planet Index – a global biodiversity indicator based on population trends in vertebrate species from around the world. It contains over 18,000 population-time series from more than 3,600 species, but only 549 reptile populations representing 194 species. Using these data, we estimated an average global decline in reptile populations of around 55% between 1970 and 2012. However, data are biased towards crocodiles, turtles and tortoises, while only 2% of all known lizard and snake species are represented in the database. Since snakes and lizards make up the majority of known reptile species, they clearly require a greater share of the research limelight. Our analysis showed that data for snakes and lizards came primarily from published ecological research, while for crocodiles, turtles and tortoises, data are mostly collected for the purpose of conservation management. We hope that through publishing this research open access, we will be able to mobilise more data to improve our representation of reptiles as a major component of vertebrate life in the Living Planet Index.

Reference

Saha, A, McRae, L, Dodd, Jr CK, Gadsden, H, Hare, KM, Lukoschek, V and Böhm, M (2018) Tracking global population trends: population time-series data and a Living Planet Index for reptiles. *Journal of Herpetology* **52**: 259-268



Estimating snare detectability for robust threat monitoring

Hunting with wire snares is rife within many tropical forest systems and constitutes a major threat to a range of vertebrate taxa. Reliable monitoring of snaring levels is critical for assessing the effectiveness of management interventions; however, monitoring snares is challenging because they are difficult to detect and often spread across large, inaccessible areas. Our field experiment in Keo Seima Wildlife Reserve in eastern Cambodia investigated how detectability might be affected by habitat type, snare type, or observer. We trialled two sets of sampling protocols in a range of field conditions and assessed two potential approaches for analysing snare encounter data. Although different observers had no

discernible effect on detection probability, detectability did vary between habitat type and snare type. Our research suggests that simple repeated counts carried out at multiple sites and analysed using binomial mixture models could provide a practical solution to the problem of monitoring snaring levels both inside and outside of protected areas. This research represents an important first step in developing improved methods of threat monitoring, and such methods are greatly needed in South-east Asia, as well as in many other regions.

Reference

O'Kelly, HJ, Rowcliffe, JM, Durant, S, and Milner-Gulland, EJ (2018) Experimental estimation of snare detectability for robust threat monitoring. *Ecology and Evolution* **8**, 1778-1785

How our science is done

Two Institute researchers, Hannah Wood and Jinliang Wang, describe their working day and explain the rewards of a career in conservation science.



‘Our current focus is on understanding how red-footed and brown boobies use the MPA’

Hannah Wood describes her fieldwork in the Chagos Archipelago

Conservation scientists are frequently discovering that successfully protecting a species requires safeguarding the habitat it lives in. Marine protected areas (MPAs) have countless benefits for oceanic and coastal environments, but choosing their location and boundaries requires knowledge about how animals use the space inside them. This is something being investigated by the Chagos Archipelago Seabird Project, of which I am a part.

For most of the year I am based at the Institute, but for three months I escape my desk to collect data on seabirds breeding in the Indian Ocean. Applying for permits, ordering equipment and planning the logistics begins

months in advance, and then suddenly you're on a plane with a bag full of mosquito repellent, bird tags and masking tape.

Our study site is a 640,000km² MPA that encompasses around 58 islands in the British Indian Ocean Territory. Eighteen species of seabird breed across this archipelago, and our current focus is on understanding how red-footed boobies (*Sula sula*) and brown boobies (*Sula leucogaster*), breeding at different sites, use the MPA.

Our days usually begin at dawn, when we are roused from our camp beds by the chatter of red-footed boobies as they wake up and call to each other. After a quick breakfast, we head out along the beaches to survey nesting individuals.

We typically aim to deploy 40 GPS loggers and geolocators on breeding individuals



each season, which means finding suitable nest sites, catching the birds (not a task for those of a nervous disposition), attaching the loggers, and recording biometrics.

Once the loggers are in place, we wait for the birds to go foraging at sea for a few days, before recapturing them to remove the tags – hopefully now full of data! Over time, we hope to get a better understanding of which are the main foraging areas within the MPA, and are therefore priorities for protection.

After a day out with the birds, we return to camp for dinner cooked over a camping stove, before going to bed to the sound of the waves on the beach and boobies squabbling as they come in to roost. It would be paradise, if it weren't for the ticks!



Jinliang Wang reflects on population genetic modelling for species conservation



Genomics is revolutionising many fields of biological and environmental research, and conservation science is no exception. Large volumes (in gigabytes) of genomic data can now be obtained efficiently and at a low cost from wild animal populations in their natural habitats, without the need of catching or even seeing the animals; for example, by collecting hair, skin or faeces. These data can be used to extract information about an endangered animal, such as its historical and current population size, structure, migration, or individual survival and reproduction, which can be used to inform the design and implementation of effective conservation management of threatened species.

'Large volumes of data can now be obtained efficiently from wild animal populations in their natural habitats'

My work focuses on developing rigorous population genetics models to analyse genomic data, although I also work closely with my students and collaborators on field and lab work, and on species including Sumatran tigers (*Panthera tigris sumatrae*) and meerkats (*Suricata suricatta*).

One dilemma in conservation genetics is that, while genomics data increase rapidly in size, the quality of the data decreases rapidly too. This is especially the case with data from next-generation sequencing and from non-invasive samples, such as faeces, feathers or museum samples. Extracting useful information from these data by filtering out 'noise' from genotyping errors and mutations is critical to ensure robust and accurate inferences. Over the years I have developed statistical methodologies, implemented in various software packages (which are available for download at zsl.org/science/software), to infer pedigrees, relatedness and inbreeding, population size, migration and admixture from error-prone marker data.

A typical working day involves population genetics modelling, statistical methodology development and testing, and/or computer programming. Such desk-based science can seem a bit dull compared to that of colleagues who work in the field; however, I like the generality of methodological studies. Instead of working on something relevant to just one species, I am able to develop methods and software that are applicable to many (if not all) species.

My work is rewarding, as the methodologies and software I have developed are now widely applied in studying a broad range of wild species, from large carnivores, fishes, marine mammals and insects to plants and trees. Many of these studies directly address the challenges facing these species, and improve our understanding of the conservation support needed to ensure their survival into the future.

Education and training

Educating the next generation of conservation scientists is central to the Institute's work. Here, we look at student achievements over the past academic year.

Our PhD students

Postgraduate tutor **Guy Cowlshaw** shares the latest news from our PhD students.

It has been an eventful year for our PhD student community. The biggest landmark has been the opening of the Student Hub. Two years in the planning, purpose-built for PhD students and involving the complete refurbishment of our Nuffield Building's lower floor, the new Student Hub is a state-of-the-art space for our PhD student community. It comprises a large open-plan office with desks for 23 students, plus small and large meeting rooms, providing a dedicated communal space for our students to study and interact with one another.

In October, my fellow postgraduate tutor, Patricia Brekke, stepped down as she went on maternity leave. Patricia has been outstanding in this role: dynamic, compassionate and inspirational, and one of the two masterminds behind the Student Hub (along with my predecessor, Jon Bielby). It is hard to imagine a more fitting successor than Becki Lawson (see page 6), and we are delighted to welcome her to the role.

The PhD students have been as busy as ever, not only in their research, but also in the wider academic and social life of the Institute. A sample of these activities includes the organisation of the monthly PhD student lunches (inviting guests from across ZSL to meet our students), the co-organisation of the Institute's fortnightly lunchtime speedtalks, participation in the Institute's Athena SWAN Self-Assessment Team (see also page 6), and contributions to a variety of public outreach events at ZSL and beyond.

An important highlight of our calendar is the annual PhD Student Conference, held in February. Organised by students Guilherme Ferreira, Claudia Martina and Daniella Rabaiotti, it was an action-packed day, with 15 excellent talks from first- to fourth-year students on topics including how climate change interacts with land use to precipitate biodiversity loss; how modelling rabies in



African wild dogs can inform conservation management; visitor impacts on large mammals in a Brazilian national park; and developing new methods to address conflicts between pastoralists and wolves in rural Italy. The conference ended with our first conference quiz and awards for the best student presentations.

New arrivals and completed PhDs

This year we have been joined by 18 new PhD students. Eight of these came from the Natural Environment Research Council (NERC) London Doctoral Training Partnership (DTP), three came from the NERC Centre for Doctoral Training in Quantitative and Modelling Skills in Ecology and Evolution, and a further seven came from a variety of DTPs, institutions and funding schemes.

Meanwhile, eight of our students successfully completed their PhDs: Lewis Campbell (An investigation into the impacts of an emerging viral pathogen on wild populations of UK common frog), Charlotte Clarke (Investigating the host-parasite dynamics of a novel amphibian dermocyctid

disease in an isolated population of palmate newts in the UK), Helen Gath (Conservation management of the endangered Mauritius parakeet), Gianfranco Gliozzo (Leveraging the value of crowdsourced geographic information to detect cultural ecosystem services), James Hansford (Diversity and extinction in Madagascar's elephant birds), Sahil Nijhawan (Human-animal relations and the role of cultural norms in tiger conservation in the Idu Mishmi of Arunachal Pradesh, India), Helen O'Neill (Making connections: conserving landscapes for wide-ranging species) and Juliet Wright (The role of livelihood interventions within complex social-ecological systems). Read more about Helen and James' research on the right. Each year our PhD students produce high-quality research that makes a real difference to conservation – we are enormously proud of their achievements.

Learn more about our postgraduate opportunities at zsl.org/science/postgraduate-study

Far left: our new open-plan office space for PhD students. Top right: James Hansford (inset) has been researching Madagascar's long-extinct elephant birds.

Bottom right: Helen O'Neill (inset) used GPS tracking collars in the field to monitor African wild dog and cheetah movements

After identifying several extinct species, James Hansford reveals how these long-dead animals can shed new light on today's conservation efforts.

Investigating Madagascar's extinct giant 'elephant birds' – which science has nearly forgotten for 80 years – has been a considerable challenge. While measuring bones in dusty old museum collections around the world and developing new machine-learning methods to study their diversity, I have discovered four species, including the world's biggest-ever bird, which was heavier than some sauropod dinosaurs at over 800kg. I also recorded evidence of primitive hunting and butchery that was over 10,500 years old, extending Madagascar's archaeological record by 7,000 years. Elephant birds are now teaching us a great deal about the undisturbed state of Madagascar's ecosystems and I hope that this research can support their conservation and regeneration.

'Elephant birds are teaching us a great deal about Madagascar's ecosystems'



'Landscapes are becoming ever more human dominated'



From fenced-off habitats to illegal wildlife trade, Helen O'Neill's research on human impacts on the natural world has led to a permanent role at ZSL.

The world is changing and its landscapes are becoming ever more human dominated. Understanding how threatened species are affected by these changes is vital for successful conservation planning. My PhD focused on African wild dogs and cheetahs living in a human-dominated landscape in northern Kenya. Using GPS collar data, I was able to look at how wild dogs and cheetahs move through and use the landscape, as well as how they are affected by features such as fences and roads. I am now working for ZSL, with the focus of my work shifting towards combating the illegal wildlife trade. I am currently developing a toolkit for CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) to address the illegal trade in cheetahs, and have just started work as ZSL's pangolin technical specialist.



Our MSc courses

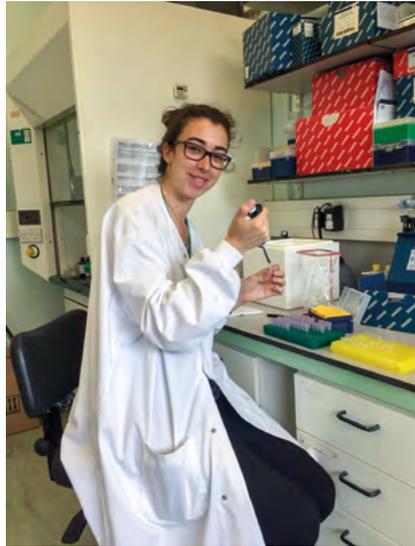
MSc courses in Wild Animal Biology and Wild Animal Health

Over the past 24 years, more than 450 students from across 61 countries and six continents have graduated from our MSc courses in Wild Animal Biology (WAB) and Wild Animal Health (WAH). In 2017, 17 students took the MSc WAB, of which four were awarded a merit, 12 passed and one deferred. Seven students took the MSc WAH, of which six received a merit and one deferred. Lucy Eckersley received the award for the MSc WAB student with the highest aggregate marks, and Allan Muir gained the most marks for the MSc WAH.

The best research project prizes were awarded to Kari Soennichsen (MSc WAB), for her project on comparative feeding ecology and morphometrics of *Lyciasalamandra* species from Anatolia and Greece, and to Berta Blanch (MSc WAH), for her study on genetic diversity and population structure of *Angiostrongylus vasorum* parasites in urban foxes (*Vulpes vulpes*) in London. Recent analysis of graduate career destinations shows that 85% of WAH and 88% of WAB graduates have gained posts in wild animal health or conservation (of 360 graduates surveyed), forming a valuable global network of wild animal health professionals, contactable through Wild Animal Alumni.

Interventions in Wild Animal Health field course

In February, ZSL ran the third Interventions in Wild Animal Health field course in the beautiful setting of Sariska National Park, Rajasthan, India, in collaboration with the Wildlife Institute of India and the University of Edinburgh. Twenty-four veterinarians attended and received in-depth, practical tuition in population monitoring, surveillance of wild animal disease, and physical and



chemical restraint of wild animals. Of the attendees, 14 veterinarians were from biodiverse developing countries – including India, Afghanistan, Kenya and Indonesia – where increased capacity of wildlife health professionals is urgently needed.

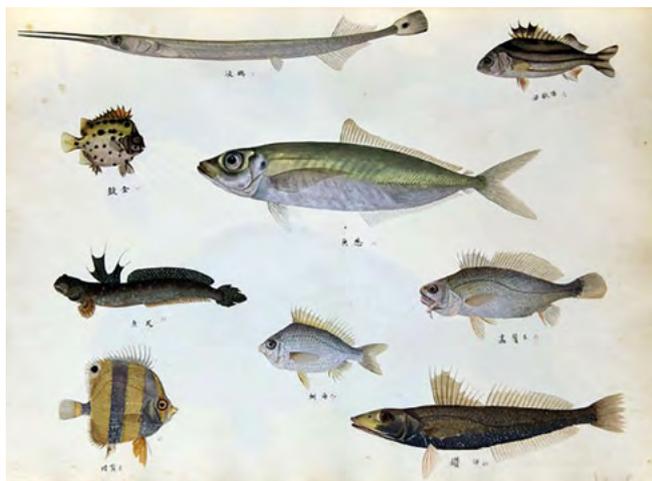
MSc course in Conservation Science

The MSc course in Conservation Science, run in partnership with Imperial College London, the Royal Botanic Gardens Kew and Durrell Wildlife Conservation Trust, remains popular with students focused on starting or enhancing their careers in conservation

research and action. The 2017 cohort included students from India, Iran, the USA and several European countries, as well as the UK. In all, 30 students graduated, with the award of 10 Distinctions and 20 Merits. Gabrielle Salazar was awarded the TH Huxley prize for the best student overall, and Oliver Metcalf was awarded the Joseph Hooker prize for the best coursework performance. Laurence Romeo was awarded the Gerald Durrell prize for the best project, which evaluated the impacts of an agricultural subsidy on human wellbeing, livelihoods and resource use on the Kiritimati Island.

ZSL Library

ZSL's Prince Philip Zoological Library and Archive facilitates access to a diverse range of resources in zoology and provides an ideal opportunity for lifelong learning.



Our monthly Artefacts blog on the ZSL website showcases rare items in our collection. Recent posts have covered ZSL's oldest books on bird eggs, the extraordinary images of naturalist and artist Ernst Haeckel, and a celebration of animals of China.

We celebrated Darwin's birthday on 12 February with a special display, including the first edition of *On the Origin of Species*.

Librarian Ann Sylph and Deputy Librarian Emma Milnes were interviewed by Jo Wood for her podcast *Librarians with Lives*. Visit Soundcloud to hear the episode.

In June, Sarah Broadhurst, Archivist and Records Manager, presented her paper 'Hatched, matched and dispatched: animal death records in the Zoological Society of London Archive' at the

Animal History Group Summer Conference.

To celebrate World Oceans Day on 8 June, Ann collated a selection of papers for a new virtual issue of *Journal of Zoology*. The theme of the issue, 'Women and the Blue Planet', describes the contributions of women to the development of



marine zoology. The issue is freely available on our online publications hub (see bottom right).

We were pleased to describe our work to audiences at Zoo Nights at ZSL London Zoo over the summer, and we welcome visitors to enjoy the library's books and archives, and to use our resources to develop their own interest in zoology and wildlife conservation.

Visit the online library catalogue at library.zsl.org

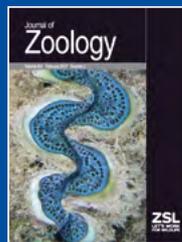
Scientific publications

ZSL publishes scientific journals that feature the latest research in zoology and conservation science.



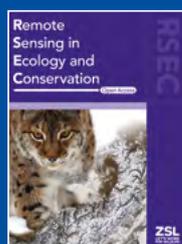
Animal Conservation

Animal Conservation publishes quantitative research on the conservation of species and habitats. Now celebrating its 20th anniversary, the journal includes feature papers and 'Letters from the Conservation Front Line' to highlight research questions that are important to the conservation practitioner community.



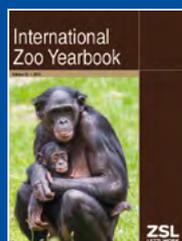
Journal of Zoology

Our monthly journal includes studies that advance our understanding of animals and their systems. Special features include a series of Hidden Gems from the archives, and a journal blog and podcast.



Remote Sensing in Ecology and Conservation

Our open-access journal provides a new platform for innovative science at the interface between ecology, conservation and remote sensing. Read the latest research at resjournal.com



International Zoo Yearbook

An invaluable resource for researchers, animal managers and anyone interested in ex situ wildlife conservation, the latest volume presents research projects and case studies on the management and conservation of great apes.

For more information on our publications, visit zslpublications.onlinelibrary.wiley.com

Communicating science

We are committed to sharing our cutting-edge science with a range of audiences, including conservation professionals, policymakers and the public. Over the past year we have showcased our research at national science festivals and organised events to promote women in science.



Cheltenham Science Festival

Humans have the potential to drive animal populations to collapse, but we can also protect and conserve them – and, one day, possibly even bring them back from extinction. The Institute’s reintroduction specialist, John Ewen, joined anthropologist Alice Roberts, science journalist Gaia Vince and author Helen Pilcher in a fun exploration of the complicated relationship we have with the animal kingdom at this year’s Cheltenham Science Festival. John showcased our work on New Zealand hihi and Mauritius parakeet; to learn more about these projects, see pages 10-11.



New Scientist Live

Visitors to the New Scientist Live event at ExCeL London enjoyed the opportunity to learn about our research to combat emerging disease threats through the Garden Wildlife Health partnership (see pages 14-15) and hear about work on disease-risk analysis and health surveillance for species interventions (DRAHS).



Stamford Raffles Lecture

The Stamford Raffles Lecture is the foremost event in ZSL’s programme of scientific events. The 2018 lecture, ‘Collaborators and con-artists: coevolution as an engine of biodiversity’, given by Claire Spottiswoode of the University of Cape Town and University of Cambridge, described the ways in which coevolution can generate beautiful adaptations and help power the diversification of life.

Top right: women scientists hit the streets for our Soapbox Science event. Centre right: collaborating for conservation in China and protecting its endemic

species, such as the brown-eared pheasant (*Crossoptilon manchuricum*), was the focus of a recent ZSL event.

Bottom right: CSI of the Sea

Soapbox Science

The 2018 season of Soapbox Science, our public outreach platform for promoting women scientists, has been our biggest year to date, with 30 events around the globe, including new events in Sweden, Tanzania and the USA. Soapbox Science transforms public spaces into arenas for public learning and scientific debate, giving everyone the opportunity to interact with, and be inspired by, leading women scientists. Our new Art and Science Events also appeared at six arts festivals, pairing scientists with artists in order to explore innovative and engaging ways to get the public excited about science.



Science and conservation events

ZSL's popular science and conservation events are free and open to the public. Each meeting highlights the latest developments in conservation and zoological research. This year's programme included lectures on 'Collaborating for conservation in China', 'Ecosystems under the microscope: why microbes matter for conservation', 'Cetacean by-catch: casting the net for solutions' and 'Wildlife and wellbeing in urban landscapes'.

Symposia

ZSL's symposia bring together teams of international experts to discuss important topics in conservation science. In February the symposium 'Safeguarding space for nature, securing our future: developing a post-2020 strategy' brought together scientists, conservation practitioners, policymakers and business leaders to review the science informing future area-based conservation targets, evaluate the implications of policy options and raise awareness of the need for a more ambitious strategy to safeguard space for nature.

CSI of the Sea

A number of CSI of the Sea events were held during the year to highlight the important work of the Cetacean Strandings Investigation Programme (CSIP). Our online-only event, held during British Science Week, featured a dolphin post-mortem taking place in real time. CSIP, run by the Institute since its inception in 1990, coordinates the investigation of all cetaceans, marine turtles and basking sharks that strand around the UK coastline. See [zsl.org/science/whats-on/csi-of-the-sea-online-event](https://www.zsl.org/science/whats-on/csi-of-the-sea-online-event) for more information.



ZSL Scientific Awards

ZSL recognises outstanding achievement in conservation science through its annual presentation of awards. The following awards were presented at our award ceremony in June 2018.

ZSL Frink Award

The Society's highest award, presented to a professional zoologist for substantial and original contributions to zoology. Awarded to Pat Monaghan, University of Glasgow, for outstanding contributions to behavioural and evolutionary ecology.

ZSL Scientific Medal

Presented to scientists with up to 15 years' postdoctoral experience for distinguished work in zoology. Awarded to Anjali Goswami, Natural History Museum, for advancing our understanding of palaeobiology and macroecology; Andrea Manica, University of Cambridge, for outstanding research on animal movement strategies, population genetics and spatial ecology; and Richard Pearson, University College London, for influential research on the impacts of climate change on biodiversity.



ZSL Silver Medal

Awarded for contributions to the understanding and appreciation of zoology. Presented to Steve Jones FRS, University College London, for major contributions to science communication.

ZSL Marsh Award for Conservation Biology

For fundamental science and its application to the conservation of animal species and habitats. Awarded to Susan Cheyne of Borneo Nature Foundation and Oxford Brookes University, for contributions to gibbon conservation, capacity building and conservation policy.



ZSL Marsh Award for Marine and Freshwater Conservation

For fundamental science and its application to conservation in marine and/or freshwater ecosystems. Awarded to Sascha Hooker, University of St Andrews, for influential research that informs policy on marine protected areas and marine mammal conservation.

ZSL Stamford Raffles Award

Awarded to an individual for distinguished contributions to zoology outside the scope of their profession. Presented to Paul Brock for significant contributions to entomology.

ZSL Prince Philip Award and Marsh Prize

Awarded to an A-Level (or Higher) student for an outstanding biology project. Awarded to Jemima Frame, Streatham and Clapham High School, for her project 'To what extent does diet affect activity levels in a domestic cat?.'

ZSL Charles Darwin Award and Marsh Prize

Presented for the best zoological project by an undergraduate student attending university in the UK. Awarded to Joe Wynn, University of Oxford, for his project 'Gone with the wind: how a pelagic seabird reacts to weather.'

ZSL Thomas Henry Huxley Award and Marsh Prize

Presented for the best zoological doctoral thesis produced in the UK. Awarded to Shana Caro, University of Oxford, for her thesis 'Social and environmental factors in the evolution of signalling'.

ZSL Clarivate Award for Communicating Zoology

Presented for a book or film of a zoological nature that has an outstanding impact on a general audience. Awarded to Mark Brownlow and James Honeyborne, executive producers of *Blue Planet II*.



ZSL Award for Outstanding Contributions to the Zoo Community

Awarded for outstanding, long-term contributions to the international zoo and aquarium community. Presented to Bryan Carroll, Bristol Zoological Society, for advancing the role of zoos in species conservation.

ZSL Award for Conservation Innovation

Awarded for the development of practical conservation tools or approaches that have had a major conservation impact. Presented to Mark Stanley Price, University of Oxford, for groundbreaking contributions to conservation translocations.

ZSL would like to thank the Marsh Christian Trust and Clarivate Analytics for their generous support of our scientific awards programme

Funding

The Institute depends on funding from a wide source of donors, including the Higher Education Funding Council for England, to carry out its research.

Cetacean Strandings Investigation Programme

The Cetacean Strandings Investigation Programme (CSIP), initiated in 1990, is a collaborative research programme coordinated by scientists from the Institute and working alongside partner organisations the Natural History Museum, Scotland's Rural College, Marine Environmental Monitoring in Wales, the Cornwall Wildlife Trust Marine Strandings Network and the University of Exeter.

It is tasked with the investigation of UK stranded cetaceans, marine turtles and basking sharks through forensic post-mortem examinations of selected individuals and from these, learn more about the threats they face in UK waters. During 2017, CSIP staff at the Institute led negotiations that resulted

in the award of a new three-year contract with Defra and the Devolved Governments of Scotland and Wales. The contract award of £1,214,648 will enable the CSIP to continue its investigation of anthropogenic drivers of mortality, which range from accidental entanglement in fishing gear and ship-strike to the impacts of persistent organic pollutants such as polychlorinated biphenyls. The project remit has also been expanded to encompass research into strandings of other large-bodied shark species, such as the porbeagle (*Lamna nasus*). During the course of the next contract period, the current national strandings database will also be upgraded, to allow direct export and display of information on UK strandings to the public.

See zsl.org/csip



Importance of the British Indian Ocean Territory (BIOT) Marine Protected Area for seabirds

Seabirds are crucial indicators of marine ecosystem health. However, seabird populations are decreasing faster than any comparable group of birds, with monitored populations declining by about 70% since 1950. Tropical seabird populations are part of this worrying trend, and the western Indian Ocean currently supports 19 million breeding seabirds of 30 species, making it one of the most significant tropical seabird assemblages in the world. Large marine protected areas (MPAs) have been proposed as one important

component of seabird conservation, but their efficacy remains largely untested. In the western Indian Ocean, the largest MPA (640,000km²) surrounds the 55 islands of the BIOT, including breeding colonies of 18 seabird species. However, data on the use of the MPA by seabirds are extremely limited, and provide no indication of its efficacy as a conservation tool. A four-year research programme is being funded (with £639,000) by the Bertarelli Foundation as part of the Bertarelli Programme in Marine Science, to assess how seabirds utilise the MPA year-round, and hence its regional value for seabird conservation.

Funding organisations

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UK and Canada Arctic Partnership
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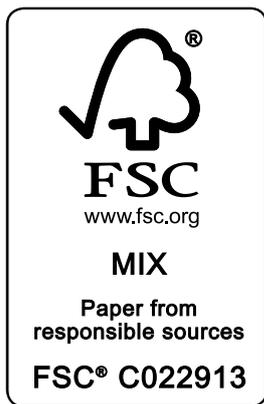
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