We have worked with the ESI on two major programmes, and look forward to continuing the relationship with further projects. The ESI obviously has academic and subject matter expertise, but this isn't what makes the engagements so successful. It is the professional, collaborative and enthusiastic approach which the team brings that makes the difference. This culture and approach meant that the knowledge and capabilities of all parties came together in delivering a successful outcome.

Kevin Fitzpatrick COO, NJW

The ESI has proved an invaluable partner in developing our understanding of the natural assets of Cornwall and the Isles of Scilly, increasing both the quantity and quality of the knowledge we hold about our natural environment, its biodiversity and the actions we should take to enhance them.

Matthew Thomson, Chair, Cornwall and Isles of Scilly Local Nature Partnership

We are proud that the ESI provides a hub to showcase the world class research in environment and sustainability that is taking place at the University of Exeter. The partnerships with local businesses and community are essential to ensure our work is relevant and innovative for Cornwall and the South West region.

Professor Mark Goodwin, Deputy Vice Chancellor (External Engagement), University of Exeter

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Accuracy of information

Every effort has been made to ensure that the information contained in this booklet is correct at the time of going to print.

If you require this publication in a different format, please contact **esienquiries@exeter.ac.uk**
For general enquiries regarding business engagement and support, please contact the Innovation, Impact and Business team at **business@exeter.ac.uk**

2018C-ANS077

UNIVERSITY OF EXETER | ENVIRONMENT AND SUSTAINABILITY INSTITUTE

Annual Review

European Regional Development Fund
Investing in your Future

convergence
for economic transformation

The University of Exeter's Environment and Sustainability Institute (ESI) is a unique facility bringing together a diverse, interdisciplinary group of researchers dedicated to finding solutions to problems of environmental change. Based at the University's Penryn Campus in Cornwall, our world-class work is enhancing people's lives by improving their relationships with the environment.

The ESI has been funded by the European Regional Development Fund Convergence Programme (£22.9m) and the South West Regional Development Agency (£6.6m), with significant support from the Higher Education Funding Council for England.

www.exeter.ac.uk/esi

Director's Overview

I was delighted to be appointed as the second Director of the ESI in May 2017, and have watched ESI strengthen and grow since it opened five years ago. The ESI continues to thrive as a hub of environmental innovation and activity, with world-leading researchers and their students focusing on the complex interdisciplinary challenges of protecting and enhancing our environment both nationally and internationally. At the same time, we retain our local focus on enhancing the environmental, economic and educational futures of communities in Cornwall and the South West.

We have a growing number of Impact Fellows in the ESI team, and affiliates, who work directly at the interface between research and its application within local organisations, businesses and communities. This way of working has deepened our relationship with the Local Nature Partnership and Cornwall Council as they implement their innovative environmental growth strategy. We are also proud of ESI's first potential spin-out company, BuildSolar, developing solar bricks as a means of integrating solar power generation into the fabric of new buildings – an exciting new prospect for reducing our carbon footprint.

Fundamental to nurturing a healthy environment and society, is ensuring that environmental and sustainability issues are prominent in our education, at all levels. The ESI can play a key role in this arena, from schools to adult education, and we are developing routes by which we contribute to the region's environmental knowledge economy. Our website has more examples of the work we are doing, the opportunities to get involved, and shows how ESI staff and students are part of a larger community of environmental researchers and students at the University of Exeter's Penryn Campus, all tackling the key global challenges of our time across land and sea.

Professor Juliet Osborne

Strategy
Our Aims

In an era of unprecedented environmental and societal change, the ESI's overarching aim is to provide insight and solutions to meet the challenges we face in securing a sustainable future.

We are:

- Addressing challenges of environmental and social change over time and over a range of scales, from local to global.
- Developing strategies for biological, technological, political and social innovations that promote responsible stewardship of terrestrial and marine systems.
- Recognising and building on the role of the environment in promoting human health, prosperity and well-being.
- Using our research to help build positive and productive futures for the economy, environment and education of Cornish communities.

Whilst much of our research and impact is national or international, Cornwall and the Isles of Scilly are at the very heart of our endeavours. All of our research is either specific to a challenge faced in Cornwall but that has global impact and consequences, or global research that has impacts on the communities and environment in Cornwall. ■

Strategy
Our Research Themes

The ESI's four key research themes provide us with a focus on particular challenges that we need to address, in order to meet our aim of securing a sustainable future in an era of rapid environmental change.

Energy, materials and resources

It is essential that we use fewer resources more efficiently, with less damage to the environment and greater benefits to society to enable sustainable futures across the globe. This theme includes work that spans clean technologies, bioremediation, reducing waste and developing methods of use that reduce environmental impact or harm.

Biodiversity and ecosystem services

Environmental change threatens biodiversity and 'Natural Capital' in terrestrial, fresh water and marine ecosystems. This theme covers the measurement, monitoring and modelling of biodiversity, ecological processes and the benefits that nature affords humans under different environmental change scenarios.

Environmental Stewardship and Citizenship

Human activity largely triggers rapid environmental change. Humans are also responsible for the regulation, management and maintenance of various environments across the globe. This theme examines the conflicts and opportunities posed by environmental stewardship: exploring how humans interact with land, sea and natural capital, and whether those interactions can be improved for environmental and social sustainability.

Ecosystem Health

Pollution and disease dynamics in individual populations or communities of animals, plants or microbes can degrade healthy, functioning ecosystems and also affect the balance of natural capital. They can alter the production of food, fuel and timber in both aquatic and terrestrial systems. This theme investigates disease load, microbe communities and pollution to finding robust management strategies over the long-term.

Our regular Think Tank events, supported by The Halpin Trust, bring together researchers and partners from across the University and community to explore concepts that cut across all four of our themes. ■

Interdisciplinary Case Studies

The problems and challenges created by environmental change do not fit neatly into one academic discipline, so neither does our research. Interdisciplinarity is central to all four of our research themes. The ESI building houses researchers with backgrounds in fields as various as Geography, Mathematics, Mining, Renewable Energy, Ecology, Microbiology, Politics, Business and Health. The ESI brings these disciplines together under our central aim to provide solutions and insights on environmental and social change to provide a sustainable future.

Photo courtesy of Nina Constable Media.

Designing a Sensibility for Sustainable Clothing

This project (funded by the AHRC) involves academic researchers (led by Prof C Saunders and Dr J Willett of ESI) working with a range of community members, textile designers, environmental NGOs and others to use creative practices to encourage people to think, feel and act more sustainably in relation to their clothing. It draws on the expertise of academic staff from disciplines including political science, political theory, art and design, textiles and cultural geography. The project's opening symposium was held in January 2018 and it identified a need to educate on the negative effects of the fashion industry, but not negatively. Instead, positive solutions need to be promoted. In this light, it was suggested that durable, mended and modified clothes should be celebrated as a 'new cool'. There were also suggestions to alter the supply-demand dynamics of clothing. If we can stop buying fast fashion, it might slow down. Empathy also needs to be developed with those who make our clothes on our behalf. At the end of the project the findings will be fed back to policy-makers, who are already keen to learn about ways to encourage pro-environmental behaviours. ■

Social scientists, ecologists and geographers (Prof C Saunders, Prof R McDonald, Prof S Hinchliffe) have been working together on how to reduce conflict in the debate about how to best control bovine tuberculosis in cattle (bTB). The policy to cull badgers has been hugely controversial. Media portrayals constantly pitch cull supporters and opponents against one another, exacerbating an already prevalent sense of polarisation and intractability. The popular impression is that cull supporters and cull opponents have largely talked past one another and that there is no common ground.

The Economic and Social Research Council (ESRC) sponsored work has illustrated that the debate is not as polarised as has been suggested. We used survey and statistical methods to identify three distinct viewpoints, with clear areas of overlap. There is warmth for collaboration to improve bTB policy: all parties agree that whole-herd culling of cattle is unacceptable. A forum involving people representing the full-range of viewpoints across Devon converged on the need to share data on affected farms, share access to relevant science; and develop a broad-based working group to collaborate on action to reduce bTB. ■

Energy and Clean Water for India

This research on environmental sustainability challenges in India is a collaboration between Dr David Benson (a social scientist), Professor Tapas Mallick (a physicist) and Dr Senthil Sundaram (an engineer) working with non-academic partners, in two main areas.

Firstly, the researchers are investigating the socio-economic sustainability of solutions for wastewater treatment in India. The researchers are collating evidence for the benefits of anaerobic digestion, hydrothermal carbonization and algal bioremediation techniques for treating textile production effluent, which poses a particular threat to sustainable development in Tamil Nadu.

Secondly, the team are sharing knowledge with industry partners in India on the potential benefits of innovative UK dairy production techniques, as a basis for enhancing sector profitability in India. In contrast to the UK, milk productivity in India is low while the demand for 'added value' dairy products is growing, providing significant research and commercial opportunities. Several key areas have been identified in which UK technologies can support Indian dairy production, most notably concerning animal nutrition, animal husbandry, robotic milking, renewable energy provision and wastewater treatment. This is now informing ESI-based research to produce prototype off-grid, solar PV-powered chilling equipment for milk production to support local scale

dairy production in India. This is often constrained by lack of access to reliable, affordable energy for milk processing.

Local Research for Global Impact

ESI is engaged in several regional partnership projects which offer a great opportunity for ESI's researchers to work closely with regional partners, businesses and stakeholders. These collaborations enable researchers to gain insights into the complexities of delivering projects that seek to drive regional economic, social and environmental change, but also give partnering organisations the ability to ensure their delivery is supported by the best possible evidence and scientific insight. Our involvement is diverse and far-reaching, covering a wide range of sectors and socio-ecological issues including agriculture, food security, biodiversity, skills and e-health. ■

Green Infrastructure for Growth is a £3.5m programme led by Cornwall Council that seeks to deliver a major investment in publicly owned and managed urban green space in the towns of Bude, Camborne, Hayle, Penzance, Pool, Redruth and Saltash, increasing their wildlife value, accessibility and community enjoyment. Dr Rosalind Shaw, Professor Juliet Osborne, Dr Ilya Maclean, Professor Kevin Gaston and Dr Ben Wheeler from the ECEHH are all working with Cornwall Council to ensure the impacts of this investment are robustly monitored and the positive effects on wildlife and people are maximised.

Photo: Night shot of Plymouth by James Duffy

Environmental Growth for Business is a £3m three-year programme led by the University in partnership with Cornwall Council, Cornwall Wildlife Trust and Cornwall Development Company. The project works with new and existing businesses, adopting an 'ecosystem services' and 'circular economics' approach to identifying opportunities for increased productivity and economic resilience, through improvements in resource efficiency. Additionally it provides opportunities for delivering business-led environmental growth and development of products and services in response to regional environmental challenges. This project is of key importance in supporting the delivery of Cornwall's Environmental Growth Strategy 2016 – 2065 and engages a wide range of ESI researchers and the University's Business School.

SMARTLINE (£4.7m) aims to identify the requirements and market potential for new eHealth/eWellbeing products and services, stimulate business development, identify skills gaps and create jobs. The partner organisations are; Coastline Housing Ltd, Cornwall Council, University of Exeter, and Volunteer Cornwall.

Widening Participation through Skills (£1.8m) seeks, alongside Plymouth University, Truro and Penwith College and The Cornwall College Group, to improve pathways from vocational programmes to foundation degrees (and beyond) and to increase access for all to Higher Education (HE) via innovative access routes. The ESI is running a range of workshops and modules, such as Real World Mathematics (Stuart Townley) and Political Participation in My Community (Joanie Willett).

Food for Change (£1.3m) involves ESI social scientists, working alongside researchers from Geography, the ECEHH and Cornwall Food Foundation. This multi-partner project is working with a number of social enterprises, charities and social care providers to build six locally-based food partnerships from Camborne to Liskeard. These will enable users of foodbanks and mental health and other social services to address barriers to their active inclusion in the economy through practical, sensitive, solution-focused packages of food-based training, volunteering and work experience. ■

Global Research for Local Impact

The ESI works with partners across the world and our research this year has taken us from fishing communities in South-East Asia and feral dogs in Chad to tracking basking sharks off Uruguay and Scotland to speaking at UN committees in Bangkok and Nairobi. While this research is international, it can have a direct impact here in Cornwall – whether that be in creating jobs, helping grow the GDP or expanding Cornwall's reputation for world-leading environmental research. Outlined here are some of the collaborations we are currently undertaking with international partners.

Dr Tomas Chaigneau, Lecturer in Social Sciences for our environment, is a social scientist who studies the relationship between the natural environment and peoples' wellbeing. This involves understanding how individuals derive wellbeing from the coast but also how their actions can impact their adjacent environment.

His recent research has primarily focused along the coast and has explored the links between coastal ecosystem services and wellbeing in East Africa as part of the Sustainable Poverty Alleviation from Coastal Ecosystem Services (SPACES) project. Currently, he is using the experience gained from his PhD on the social impact of Marine Protected Areas in South East Asia to inform a new project "Blue Communities" which seeks to build capacity for sustainable interactions with marine ecosystems for the benefit of the health, wellbeing, food security and livelihoods of coastal communities in East and Southeast Asia.

The Solar group at ESI is part of the Joint UK-India Clean Energy Centre (JUICE), funded by EPSRC, and builds on their expertise in energy networks, photovoltaics and storage technologies. In India, the Department of Science and Technology (DST) is funding further India-UK collaboration on Clean Energy, and collectively these projects form the Joint Virtual Clean Energy Centre. In addition to leading on the technical side of Building Integrated Photovoltaics, the ESI team, led by Professor Tapas Mallick, is responsible for networking between the two countries, where more than 150 research exchange projects are due to take place over the next three years. This will have a wide impact on the solar energy industries, in particular the clean energy network in Cornwall, where grid limitation is a real concern.

For more information visit **www.juice-centre.org.uk**

Professor Gabriel Yvon-Durocher's research takes place in our labs in Cornwall but also incorporates working with partners and collaborators around the world. The research may have huge implications for the ocean and is therefore of vital importance to Cornwall. His team is investigating the potential for rapid adaptation to global warming in phytoplankton. Phytoplankton play a pivotal role in the ocean's biogeochemistry, taking carbon from the atmosphere and recycling nutrients that support the productivity of marine food webs. Using experimental evolution, physiology, biochemistry and genomics, they are uncovering the mechanisms that shape the evolution of elevated thermal tolerance in phytoplankton. This work will be used in models to forecast the effects of climate change on ocean biogeochemistry. ■

Focus on Our Staff

Dr. Hasan Baig

Buildings are responsible for a third of energy consumption and 8.6bn tonnes of carbon dioxide emissions. Transforming buildings from energy consumers to energy harvesters and generators will be crucial to our sustainable future. Hasan's research is focused on the efficiency of photovoltaic (PV) and concentrator photovoltaic (CPV) systems and their integration within building architecture and commonly used construction materials.

Solar Squared is our first patent pending (application no. UK 1705840.5) construction material based on the concept of concentrating photovoltaics, whereby sunlight is magnified and focused on a solar cell. The product replaces conventional glass blocks, widely used across the globe for several decades. It provides a low cost, secure, safe, efficient, clean energy solution for the energy-intensive built environment. Solar Squared unlocks new vertical spaces within our towns and cities for clean energy production. The bricks have low convective heat transfer, and high thermal insulation. ■

For more information visit **www.buildsolar.co.uk**

Grace Twixton-Davies

Dr Grace Twiston-Davies was awarded a NERC Innovation Internship Fellowship to collaborate with Cornwall Area of Outstanding Natural Beauty (AONB) to extend the real-world impacts of the ESI's award winning computer models of bee behaviour, growth and survival (BBSRC Innovator of the Year Social Impact 2017). Grace piloted these models as decision-support tools for farmers and land managers to enhance pollinator conservation and food production with Cornwall AONB's key stakeholders from food and farming sectors. Grace is now expanding on this work, with South Devon AONB units, Natural England and the National Farmers Union to co-design BEE-STEWARD, a computer software tool designed to help farmers compare the impact of different pollinator-friendly management on bee survival and pollination rates. This is an example of ESI working with Cornish organisations to be the first beneficiaries of this pollinator research, which can then be used more broadly on a national scale as well. ■

Stineke van Houte

Antimicrobial resistance (AMR) poses a tremendous challenge to our society. Recently, a revolutionary technology has been developed, known as CRISPR-Cas9, which can be used to eradicate genes encoding AMR from microbial communities. However, this technology has only been tested under laboratory conditions, and is not yet ready for use in the real world. Stineke was awarded a BBSRC fellowship to develop a new technology to use CRISPR-Cas9, originally discovered as a bacterial immune system, to eradicate AMR genes from a gut microbial community. It is also important to understand the potential risks associated with applying such a technology in the real world by studying the ecological and evolutionary consequences of CRISPR-Cas9 on microbial communities. The outcome of the research will provide an important step forwards in the battle against AMR. ■

Karen Anderson

Karen Anderson's DroneLab research group was contacted by BBC director Nick Kwek, who invited them to participate in a live show filmed from the BBC Radio Theatre stage in December 2017. The show was 'Click Live' – a showcase of the latest technology and gadgets, filmed in front of a live studio audience. The DroneLab demonstrated the ways that consumer grade drone technology can be adapted for 'saving the world' – Karen showed how data captured by drones can be used for addressing environmental science questions. The stage show lasted about 90 minutes, with the DroneLab team (comprising Dr Karen Anderson and Dr Andy Cunliffe, and PhD researchers Dominic Fawcett and Javier Blanco (both researchers on an EU International Training Network)) delivering a 5-10 minute stage segment to the live audience. The DroneLab contribution made the cut and a segment was shown on the Click Live TV show in January 2018. ■

Working with the Business School

We welcome Professor Stefano Pascucci to the ESI. Stefano is a Professor in Sustainability and the Circular Economy, from the University of Exeter Business School. Stefano is an applied economist who developed an interest for sustainability as connected to organisation theories, innovation management, and value chain analysis. His research focuses on agribusiness, sustainability and circular economy. The concept of the circular economy provides a new regenerative approach to our economy, seeking to close loops of energy and resource use, and reduce or eliminate waste. This is achieved through innovative design, and identifying routes for repair and re-use of materials to create value, rather than throwing it away. The Business School on the Penryn Campus has considerable expertise in this area and we are delighted that Stefano is providing a strong and focused link between the School and the ESI, ensuring that environmental and economic challenges are considered in conjunction.

Working with schools

In March, over 50 school pupils attended the ESI's 6th Environment and Sustainability Day for a day of workshops and activities on the theme 'Wasting the World Away.' The year 10 pupils from schools across Cornwall took part in workshops covering mine waste remediation, recycling and reuse, the risk of ocean plastics, and how nature recycles, before creating posters of their own on the subject of waste.

This annual event is part of the ESI's objective to build education around and relationships between Cornish communities and the natural environment. As well as offering the pupils a taste of both University and world-leading research, this was a chance for the children to see how the ESI's work will directly impact on their futures.

> **"At school the students have already been talking about plastic waste, so it was interesting to see the background behind the problems from both a local and global perspective."**
>
> Darren Gross, Teacher from Roseland Academy

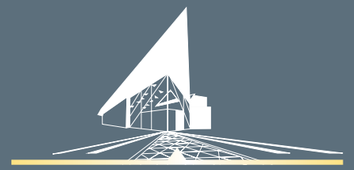
FEEDBACK FROM THE VISITING STUDENTS INCLUDED:

> "They were good workshops; they were engaging, informative and interesting. It's an important theme for the future."

> "I got to discover more about topics that I am passionate about."

> "The most enjoyable thing was gaining an understanding of recycling and learning things we don't learn in school."

The ESI in Numbers



Our staff teach on over 70 modules in undergraduate and postgraduate degree programmes at University of Exeter

Staff and students from 22 countries across 5 continents

66

media outlets published our work this year

Over £4 million of facilities for use in collaborative research projects with businesses

AWARD

9 PhDs completed and awarded in the last year

£4M Over £4 million of research awards in the 2016/17 academic year

We have worked with 64 external partners on projects in the last year

6 academic staff promotions

102 publications in the 2016/17 academic year and over 500 published papers since the ESI's inception

86 staff and 63 research students in the institute as well as 37 academic, creative, stakeholder and education affiliates across the University and community

Awards

Professor Juliet Osborne's BEEHAVE group was awarded the BBSRC Innovator of the Year Award for Social Impact 2017.

Prof Kevin Gaston was awarded the International Ecology Institute prize in Terrestrial Ecology.

Dr David Benson was given a University of Exeter Rewarding Excellence Gold Award for 'outstanding interdisciplinary research and teaching in Politics'.

Named Animal Care and Welfare Officer (NACWO) Lab Manager Amy Campbell was awarded a Professional Services Recognition Award for Challenge.

Dr Anne Leonard and Dr Aimee Murray of the European Centre for the Environment and Human Health (ECEHH) were both awarded Natural Environment Research Council (NERC) Innovation Fellowships.

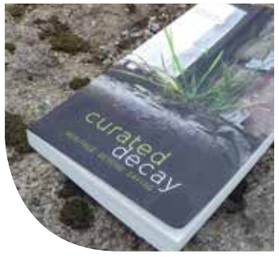
Dr Stineke van Houte was awarded a prestigious Biotechnology and Biological Sciences Research Council (BBSRC) Future Leadership Fellowship.

Prof Kevin Gaston was named among the most highly cited researchers worldwide by Clarivate Analytics.

The National Union of Students awarded the ESI their Gold award for Green Impact.

Publications

CURATED DECAY: HERITAGE BEYOND SAVING



University of Minnesota Press, 2017

Professor Caitlin DeSilvey's new book looks at how climate change, falling budgets and other pressures will mean that in the future some heritage sites cannot be protected, but that this should not always be viewed as a failure and can involve a deliberate decision to allow nature to take its course and to learn from change.

The book features case studies from Cornwall and the USA, and has received national attention in the press, online, on television and radio.

SELECTED PUBLICATIONS FROM THE ESI

Energy, Materials and Resources

Baig, H. et al. Conceptual design and performance evaluation of a hybrid concentrating photovoltaic system in preparation for energy. Energy 147, 547-560, doi:10.1016/j.energy.2017.12.127 (2018).

Frascoli, F. & Hudson-Edwards, K. A. Geochemistry, Mineralogy and Microbiology of Molybdenum in Mining-Affected Environments. Minerals 8, doi:10.3390/min8020042 (2018).

Biodiversity and Ecosystem Services

Casalegno, S., Anderson, K., Cox, D. T. C., Hancock, S. & Gaston, K. J. (2017) Ecological connectivity in the three-dimensional urban green volume using waveform airborne lidar. Scientific Reports 7, 45571

Knapp, J. L. & Osborne, J. L. (2017) Courgette Production: Pollination Demand, Supply, and Value. Journal of Economic Entomology 110, 1973-1979.

Environmental Stewardship and Citizenship

Benson, D. & Lorenzoni, I. (2017) Climate change adaptation, flood risks and policy coherence in integrated water resources management in England. Regional Environmental Change 17, 1921-1932.

Cox, D. T. C. et al. (2017) Doses of Neighborhood Nature: The Benefits for Mental Health of Living with Nature. Bioscience 67, 147-155.

Price, S., Saunders, C., Hinchliffe, S. & McDonald, R. A. (2017) From contradiction to contrast in a countryside conflict: Using Q Methodology to reveal a diplomatic space for doing TB differently. Environment and Planning A 49, 2578-2594.

Ecosystem Health

Leonard, A. F. C., Singer, A., Ukoumunne, O. C., Gaze, W. H. & Garside, R. (2018) Is it safe to go back into the water? A systematic review and meta-analysis of the risk of acquiring infections from recreational exposure to seawater. International Journal of Epidemiology 47, 572-586.

CREATIVE EXCHANGE

For five years, the ESI Creative Exchange programme has been fostering distinctive new transdisciplinary cultures by bringing together artists and researchers to explore shared questions. The programme supported five collaborations in 2017: topics ranged from local food systems to mathematical modelling, bee health to post-industrial landscape futures. In '6000 flowers', artist Jodie Purcell used pigment from plants and flowers to produce photosensitive emulsion images that engaged audiences with ongoing ESI research on bee foraging and colony survival. Colette Beckham with the Cornwall Area of Outstanding Natural Beauty (a partner in the research), commented,

"It's great to see how science and the arts can come together through a project like Jodie's, to illustrate just how important it is to find solutions to the shortages of forage that can affect Cornish bumblebees"

Seeking to deepen the programme's contribution to developing innovative methods and models of working across the arts and the sciences, we recently expanded our scope to invite proposals from all researchers on the Cornwall Campuses. Our first project in the expanded programme, 'More than food', sought to raise awareness about foodbank use and issues of social sustainability, through exhibition of a striking selection of photographs created in collaboration between photojournalist Paddy Dowling, local foodbanks and researchers in the Social Innovation Group.