

Modelling our ecological world



Dr Len Thomas, Director of the Centre for Research into Ecological and Environmental Modelling (CREEM), describes the work of this world-leading Centre

This mural by Dr Cornelia Oedekoven (see her profile opposite) puts a watchful researcher at the centre of a mathematical and ecological world. For information about each animal and symbol, please visit: creem.mural.org



This year marks the centenary of the publication of the groundbreaking text *On Growth and Form* by Sir D'Arcy Wentworth Thompson – St Andrews academic and pioneer of biomathematics. In this beautiful book he shows how the biological forms of many organisms can be described by simple physical and mathematical laws – for example, how the spiral of a nautilus or an opening fern frond relate to the Fibonacci sequence.

D'Arcy Thompson was also deeply interested in the application of mathematics to the management and conservation of wild animal populations and put this into practice in his role as scientific adviser to the government on the management of fish, seals, sea otters and whales. His work continues at the University of St Andrews today in the Centre for Research into

Ecological and Environmental Modelling (CREEM) – an interdisciplinary research centre linking the Schools of Mathematics & Statistics, Biology, Earth & Environmental Sciences and Geography & Sustainable Development.

At CREEM our goal is to develop and apply new statistical methods to address pressing ecological and environmental issues. As a result we have worked on every continent and major ecosystem from the Arctic (polar bears) to the Antarctic (minke whales) via mountains (snow leopards), jungles (rainforest trees), oceans (many marine species) and deserts (desert tortoise). Closer to home, we advise on the impact of marine renewables, measuring biodiversity and managing UK species such as grey seals and commercial fish.

Some of our major research themes are outlined below:



Counting critters

One of the most fundamental ecological questions about a wildlife population is, "How many are there?" However, many species are hard to count because they are cryptic, live in inaccessible places, have low density or all of these. 'Distance sampling' is probably the most widely used suite of survey methods and CREEM leads the research in this field and has developed Distance – the industry-standard software for the design and analysis of these surveys. The software has been downloaded by almost 50,000 users from over 110 countries. New technologies, such as remote photography, video or acoustics, also offer exciting possibilities for previously inaccessible populations.

Another method of surveying wildlife population – 'mark-recapture' – was pioneered in St Andrews by Richard Cormack (the first Professor of Statistics) in 1972 to estimate animal survival. This method typically requires repeated surveys, where we 'mark' some individuals in the population by fitting them with a unique tag, or by using their natural unique visible markings or, nowadays, by using their DNA sequences.

The need for accurate population estimates is particularly important for critically endangered species, but because they are so rare, they are often the most difficult to survey. However, one person's problem is another person's challenge: we have helped to develop methods for endemic cottontop tamarins in Colombia and vaquita porpoises in Mexico.



Trending

Another key question is, "How much are they declining or increasing?" Sometimes estimating trends is as simple as averaging out repeated population estimates. However, there is often not enough data to enable us to do this, as is the case with the UK grey seal population. The only component we have that is counted directly, via aerial photography, is un-weaned pups; to estimate adult trends we need a population model. We used a similar approach recently when we worked with the US Government to forecast recovery trajectories for dolphins affected by the Deepwater Horizon oil spill.



Space – the final frontier

The third question – essential for spatial management – is, "Where are they?" To answer this, spatial models are fitted to data and used to produce maps and to predict hotspots. We are developing methods that adapt more flexibly to local patterns and cope well with complex regions such as crenulated coastlines, as well as a new approach that allows highly complex, previously intractable, spatial models to be fitted using only moderate computer resources.

Here, five of our alumni describe the impact that their time at CREEM has had (or is having) on their careers.



1

Dr Jon Bishop, MSc 2003, PhD 2009 (2)

"I am a medical statistician at Birmingham Clinical Trials Unit where I help to design, run and analyse clinical trials that relate specifically to traumatic injury. I also provide statistical support to the NIHR Surgical Reconstruction and Microbiology Research Centre. The statistical training and strong inter-disciplinary environment at CREEM have translated directly into my work. Much of my working life has been spent collaborating with clinicians and trial unit staff to understand the statistical requirements necessary to deliver results that directly impact the medical treatment of trauma patients."



2

Dr Rachel Fewster, PhD 1998 (3)

"I moved to New Zealand after my PhD for a two-year postdoc – and never left! I am now an Associate Professor at the University of Auckland, teaching statistics and doing research in ecology, conservation, and animal behaviour. What I love most about being an academic is the opportunity to engage with a wide variety of research projects, from applied to theoretical. I can look out of my kitchen window and see the islands and forest ranges where my work is making a difference, but I also have the satisfaction of developing new statistical methods that are used by thousands of people worldwide. My time at CREEM was a great experience that set me up for a fascinating career."



3

Dr Tiago Marques, PhD 2007 (4)

"I first visited CREEM in 2001 for a conference and I was invited by Professor Steve Buckland to stay for a PhD! This was an amazing experience. It exposed me to many aspects of the Centre's activities from teaching workshops in places like Disney World and California to applying cutting-edge applied statistics research, including counting polar bears in the high Arctic. Despite living in sunny Lisbon, I have been working for the Centre since graduation. I love my work and consider it a privilege to be part of the CREEM team, where every colleague is a friend."



4

Dr Samantha Strindberg, PhD 2001 (5)

"My PhD focused on wildlife survey design. Once finished, I was able to put my experience to good use at the Wildlife Conservation Society (WCS), a US-based NGO. As a Conservation Scientist and Wildlife Statistician in the Global Conservation Program, I collaborate with WCS colleagues to protect the world's largest wild places across the globe. CREEM's research and tools have helped me to use the most effective wildlife assessment techniques for vulnerable species that are frequently wide-ranging or elusive, or both."



5



Sounds bad?

One recent focus is on the effects of human-caused underwater noise, particularly on whales and dolphins. Compared with air, water is relatively opaque to light but transparent to sound, so many marine species have evolved to use sound rather than sight to communicate, find prey and escape predators. Humans are creating increasing amounts of noise, for example from shipping, sonar and oil exploration. Working with biologists and acousticians, we have developed methods for determining the behavioural response of animals to these sounds, and for the (much harder) problem of assessing the chronic effect of multiple small disturbances at the population level.



Making a difference

New methods are little use unless they are applied. We are implementing new developments in free software and are providing relevant training, including running regular workshops in St Andrews, with over 1,000 attendees to date. We also teach worldwide, with low-cost workshops and academic exchanges in developing countries – particularly sub-Saharan Africa. Meeting practitioners produces a "virtuous circle", where limits of current methods are tested, generating new research questions, further research, and better methods.

"I believe D'Arcy Thompson would be proud of the way we are continuing his legacy"

Len Thomas

Research in CREEM
For further information,
please see:
www.creem.st-andrews.ac.uk