



PhD opportunities in Statistics at St Andrews, 2016-2017

(Updated 18th April 2017.)

Applications are welcomed for students wishing to undertake a PhD in Statistics at St Andrews. Full funding is available for well-qualified students; in addition, students may qualify for an enhanced stipend of an additional £1000 per annum over the standard UK research council stipend. We encourage applications as soon as possible to maximize your chances of being funded. UK, EU and other overseas students are all encouraged to apply. New PhD students would typically start in September 2017, but this is flexible.

Some general information about the division of statistics is given below, followed by a list of specific topics that are on offer this year. Finally, more information is given about how to apply.

Statistics at St Andrews

Statistics is a lively area of research at St Andrews. The Division of Statistics is one of three within the School of Mathematics and Statistics (www.mcs.st-and.ac.uk), and consists of 9 members of academic staff, 10 research staff and 8 PhD students. It was ranked first in Scotland in the 2008 Research Assessment Exercise (the last for which statistics was ranked separately from mathematics); the School of Mathematics and Statistics was ranked first in Scotland in the 2014 Research Assessment Framework, and is ranked 4th in the UK for 2017 by the Complete University Guide (source <http://www.thecompleteuniversityguide.co.uk>). One major research strength is in the area of statistical ecology: contained within the School is the world-leading Centre for Research into Ecological and Environmental Modelling (CREEM; www.creem.st-and.ac.uk), which is housed in tailor-made facilities at the St Andrews Observatory on the edge of the town. We are a founding member of the National Centre for Statistical Ecology (www.ncse.org.uk), a multi-institution consortium that ensures regular intellectual exchange between researchers worldwide with similar interests. Several members of CREEM are also part of the university's multi-school Centre for Biological Diversity (CBD; <http://synergy.st-andrews.ac.uk/research/cbd/>). A second research focus is in the area of Bayesian statistical inference and, relatedly, computer-intensive inference. Members of staff are also active in the fields of datamining, data smoothing, latent state models and statistical genetics. We are also building links with the Mathematical Biology research group within applied mathematics. A brief summary of the research interest of each member of staff is given at the bottom of this section; more details can be found on the school and CREEM web sites.

New PhD students join a high-calibre but friendly research environment. Training is provided in the first year in the as part of St Andrews' participation in the Scottish Mathematical Sciences Training Centre (www.smstc.ac.uk) and Academy for Postgraduate Training in Statistics (www.apt.ac.uk), the latter consisting of four one-week residential courses. Students may get the opportunity to become involved in externally-funded research as part of CREEM's consultancy group, the Research Unit for Wildlife Population Assessment (www.ruwpa.st-and.ac.uk); they may also be able to assist on statistics training workshops delivered to professional scientists both in the UK and abroad. Some PhDs are supervised jointly with scientists from other institutions, and there may be opportunities for study at those places. PhD studies are expected to last approximately 3.5 years.

St Andrews is a small, vibrant university town. It is situated on the east coast of Scotland and framed by countryside, beaches and cliffs. The town has a rich cultural heritage, having once been at the centre of Scotland's political and religious life. Today it is known around the world as the Home of Golf and a bustling student town with a distinctively cosmopolitan feel, where students and university staff account for more than 30% of the local population. The university is the oldest in Scotland and third oldest in the English speaking world. It is the top-rated university in Scotland for teaching quality and student satisfaction, and among the top rated in the UK for overall research; it regularly comes in the top few places in UK league tables compiled, for example, by broadsheet newspapers. Its international reputation for delivering high quality teaching and research and student satisfaction make it one of the most sought after destinations for prospective students from the UK, Europe and overseas.

More general information about postgraduate student life at St Andrews is given at the university web site <http://www.st-andrews.ac.uk/admissions/pg/>. A brochure about postgraduate study in mathematics and statistics is also available online, at <http://www.st-andrews.ac.uk/admissions/pg/choosing/subjectleaflets/>

Brief summary of academic staff interests in the Division of Statistics

- Rosemary Bailey – design of experiments
- David Borchers – mark-recapture, wildlife estimation, sampling methods
- Steve Buckland – biodiversity, sampling methods, computer-intensive methods
- Carl Donovan – datamining, commercial statistics, multivariate statistics
- Ian Goudie – mark-recapture, plant-capture, sequential inference
- Janine Illian – spatial statistics, biodiversity
- Monique Mackenzie – Random effects models, smoothing methods
- Michail Papathomas – Bayesian methods with application to genetics and biostatistics
- Len Thomas – wildlife (particularly acoustic) surveys, population dynamics modelling

Specific projects offered for 2016-17

We are currently looking for candidates for the following projects. In addition, prospective candidates with general interests related to those of staff members (see above) are welcome to contact them to discuss other possible projects.

Inferring the impact of varying boundary conditions based on spatial statistics and inverse modelling.

Supervisor: Janine Illian (co-supervisor: Justin Travis, University of Aberdeen)

Species' range boundaries are a consequence of ecological and evolutionary processes and, in turn, can themselves influence ecological and evolutionary processes which together yield observed patterns of individuals and genotypes. Describing and understanding ecotones, biogeographic range limits and hybrid zones are all major current topics in ecology: all involve boundary conditions and all would benefit greatly from the development of spatial statistics that can more effectively describe the unique spatial patterns associated with these boundaries. In this project we will exploit the flexibility of recently developed spatial statistical methods that allow incorporation of different boundary conditions and thus produce spatial patterns that can differ close to boundaries. The first objective will be to develop these models to be useful in an ecological context and use them to describe the spatial patterns present at a case study ecotone, a shifting range limit and a hybrid zone. The second objective is to use the spatial statistics within an inverse-modelling framework to infer the ecological processes (e.g. spatial scale of dispersal, kernel of competitive interactions) that underlie the spatial patterns found close to boundaries.

Developing flexible spatial models with complex boundary structures.

Supervisors: Janine Illian (joint with Sophie Smout, School of Biology and Beth Scott, University of Aberdeen)

Policy makers aim to reconcile human socio-economic objectives in the marine environment, and the conservation of protected/sensitive species such as marine mammals. It is increasingly clear that management must take account of the spatial complexity of ocean habitats, with boundaries including coastlines and oceanographic features and that marine species' use of this space is complex and responsive. In order to manage conservation effectively, it is crucial not only that we describe existing distributions of these species, but we must also aim to understand the processes that drive them.

This project will develop Bayesian spatial modelling methods which are flexible, can make use of independent data/knowledge to set informative priors, and facilitate understanding of uncertainty/risk. To make model fitting feasible we will develop methods within the framework of INLA (integrated nested Laplace approximation), Rue et al. 2009) extending existing spatial modelling methods (Lindgren et al., 2011)) where boundaries have different reflecting/absorbing properties or by considering the distribution of multiple species taking account of dependencies that might exist such as competitive interactions.

References:

- Rue H., Martino S. and Chopin N.: Approximate Bayesian Inference for Latent Gaussian Models Using Integrated Nested Laplace Approximations (with discussion). *Journal of the Royal Statistical Society, Series B*, 71, 319–392
- Lindgren, F., Rue, H. and Lindström, J., 2011. An explicit link between Gaussian fields and Gaussian Markov random fields: the stochastic partial differential equation approach. *Journal of the Royal Statistical Society, Series B (Statistical Methodology)*, 73 (4), pp. 423-498.

Spatially adaptive tiling.

Supervisor: Monique MacKenzie

The Joint Cetacean Protocol (JCP; <http://jncc.defra.gov.uk/page-5657>) is an ambitious modelling project that involves spatially adaptive smoothing of marine mammal geo-referenced data on a large spatial and temporal scale (approximately 1 million km² over about 30 years). Due to computational considerations, current smoothing methods (with targeted flexibility) require the modelling effort to be spread out over the entire spatial area which is likely to be sub-optimal for many locations – more flexibility is likely required in some areas. This PhD project will involve the development of a new ‘tiling’ method to handle large smoothing problems such as these, which permits spatially adaptive pieces of the surface to be individually considered and then sensibly aggregated to return a fitted surface. This project will also involve the treatment of auto-correlated data since data sets of this kind consist of data which are more similar for points close together in time and space (compared with distant points).

Spatially explicit capture-recapture method development.

Supervisor: David Borchers

Spatial capture-recapture (SCR) methods are fast replacing non-spatial capture-recapture for most wildlife surveys. The methods are developing fast and there is enormous scope for innovative method development. A PhD in this area could focus on theoretical problems such as efficient methods of dealing with random effects, modelling territoriality or spatial correlation, modelling movement, births and deaths; or it could focus on issues of important practical relevance such as survey design; or it could focus on methods for particular kinds of surveys: by acoustic detectors, for example, or by DNA sampling, or surveys using drones. Video and acoustic SCR surveys present challenges for individual identification, image and acoustic processing, and dealing with big data. There are many other potential SCR research avenues and the PhD could also focus on some other SCR-related issue of your choosing, subject to agreement with your prospective supervisor(s).

Spatial modelling for Occupancy surveys and N-mixture models using Integrated Nested Laplace Approximation.

Supervisors: David Borchers, Janine Illian, Finn Lindgren (University of Edinburgh) (To be confirmed)

We have recently developed Integrated Nested Laplace Approximation (INLA) methods and user-friendly software for spatial and spatio-temporal modelling of ecological survey data from complete counts, plot sample surveys and distance sampling surveys. This work creates a solid theoretical and software foundation for developing methods and software for spatial and spatio-temporal modelling of ecological populations using Occupancy methods, and N-mixture models. The proposed PhD would address some of the methodological and software challenges presented by this extension.

Stats-MathBio projects

The following projects represent a collaboration between the CREEM research group within statistics and the Mathematical Biology research group within applied mathematics.

Continuous time models of animal movement, applied to animal-borne tags and spatial capture recapture

Supervisors: Len Thomas and Mark Chaplain (and possibly David Borchers)

Most animals must move to forage, avoid predators and locate mates. Hence understanding animal movement is crucial to a full understanding of individual animal success and, ultimately, whole-population dynamics. Ongoing technological developments mean that increasing numbers of animal-borne tags are being applied; depending on the model these may yield noisy observations of position (via ARGOS satellite), or precise positions (via GPS), and other data such as height or depth (for diving animals), direction, acceleration, etc. Although movement occurs in continuous time, analytically tractable continuous time models tend to be overly simplistic (e.g., assuming random movement (Brownian motion)); more complex modelling tends to involve discrete time approximations. This project will investigate the potential for fitting more complex continuous time models using analysis where possible, but simulation-based inference where not. An additional application of such models is in fitting spatial capture-recapture models – these are used to estimate population size from time series of “captures” of marked individuals in a population. The capture does not have to be physical, for example identifying a uniquely-marked tiger on a series of infra-red-triggered camera traps throughout a forest. This PhD will suit students with an interest in (and prior training in) statistics and applied mathematics.

Parameterizing mathematical models of angiogenesis and diffusion, and selecting among competing models.

Supervisors: Mark Chaplain and Len Thomas

Mathematical models of angiogenesis (blood vessel development) and the diffusion of chemicals from blood to tissues are both crucial components of our ability to predict whether new drugs will work – for example drugs that target cancer. These models are typically formulated as stochastic differential equations, with model parameters that govern the how the quantities modelled evolve over time. These model parameters are traditionally set in an ad hoc manner, using “reasonable” values and tuning them to achieve an approximate match to data. This project aims to improve upon this process, by leveraging fitting and optimization techniques from statistics. In particular, Approximate Bayesian Computation (ABC) appears to offer strong potential for a rigorous yet flexible fitting mechanism for such complex models. In addition to model fitting, the project will also address the question of how to choose among competing models in a rigorous manner, leveraging

model selection techniques from statistics. This PhD will work at the interface between mathematical biology and applied statistics.

Centre for Biological Diversity-specific projects

The following projects are based within the Centre for Biological Diversity; the primary supervising school may not be Mathematics and Statistics. Please contact us for more details if you are interested in one of these projects.

Quantifying temporal turnover in biodiversity, and how it varies spatially.

Supervisors: Steve Buckland (co-supervisor Anne Magurran, Biology, University of St Andrews)

Climate change generates turnover in biodiversity. To develop adaptation measures, it is useful to quantify the rate of turnover, and to identify those habitats and communities that show greatest turnover. Most turnover measures seek to measure changes in species ranges, but this is an insensitive way to quantify turnover, both because changes are evident in abundances of species long before they disappear from an area, and because species tend to be sparsely distributed close to the edge of their range, and monitoring is not efficient for sampling sparsely-distributed species. Yuan, Buckland and Foss (in prep.) developed families of turnover measures based on species proportions. These measures are sensitive to changes in common species, and hence to changes in the composition of communities. The project will explore the properties of the different measures, to determine which are most effective for quantifying the effects of climate change on communities. It will also consider whether measures can be developed to quantify the effective northward-movement rate of communities.

Visualizing movement interaction for biodiversity.

Supervisors: Urška Demšar and Jed Long (Geography and Geosciences), Janine Illian (Statistics)

Recent developments in positioning sensor technologies have enabled location-tracking at an unprecedented level of detail. These advances have allowed for great strides in the field of movement ecology, which studies the movement of individuals and groups across different animal species, different scales of space and time and different levels of complexity. Observing animal movement leads to improved understanding not only of properties of movement of an individual animal but also in how observed individuals interact with each other and with other co-located species. These are crucial factors in understanding the spatio-temporal dynamics of inter- and intra-species interactions in the competition for resources. Methods for visualisation of interaction are lagging behind sensor development due to the complexity of the task, in particular since movement data are often complemented with additional animal-borne sensor data (e.g. oceanographic sensors and accelerometers). This project will use advances in information visualisation to develop new methods for visualising interaction in movement. The aim is to develop new visualisations of movement and other sensor data which will allow identification of spatio-temporal patterns in interaction between animal species and thus allow new insights into the dynamics of biodiversity.

The methods will be tested on a case study on interaction of two species of seals: grey seals and harbour seals.

The influence of body condition on functional behavioural decisions of animals.

Supervisors: Nathan Bailey and Patrick Miller (Biology), Len Thomas (Statistics)

The goal of this project is to combine theoretical development with laboratory experiments with an appropriate model organism to predict and evaluate the role of body condition on behaviour. In animals, there is expected to be a fundamental trade-off between foraging and anti-predator vigilance and behaviour. Energy-store body condition of individuals is predicted based upon existing theory to influence such functional behavioural decisions (Houston et al., 1993; Proc Roy Soc B). By more explicitly developing and testing fundamental theoretical predictions, this project will add value by providing more advanced tools to interpret the biological significance of measures of body condition made with free-ranging animals across a wide range of taxa. Thus, the project will improve our ability to monitor the health status of living animals, aiding in conservation applications.

Application procedure

Although there is no fixed deadline, you are strongly encouraged to make your application as early as possible!

Many details of the general requirements and admissions procedure are given at the university web site <https://www.st-andrews.ac.uk/study/pg/apply/research/>

Applicants should have a good first degree (UK class 2:1 or better, or international equivalent) in mathematics, statistics or another scientific discipline with a substantial numerical component. Applicants with degrees in other subjects, such as biology, are invited to discuss their qualifications with the Postgraduate Officer (contact details below). A masters' level degree (MSc, etc.) is an advantage, as is any other relevant professional experience. Please note that our primary criterion for selection is academic excellence; most successful applicants have a good to very good 1st class undergraduate degree and/or a distinction at MSc level. Those who do not have English as a first language, and who have not undertaken an undergraduate or graduate degree taught in English, should provide evidence of English proficiency (minimum IELTS 6.5 or equivalent).

Potential applicants are encouraged to contact the Postgraduate Officer responsible for PhDs in Statistics, in advance of making a formal application. He is: Len Thomas, email len.thomas@st-andrews.ac.uk, tel. 01334 461801.

To make a formal application, complete the appropriate online form at <https://www.st-andrews.ac.uk/study/pg/apply/research/> (click on "Apply Now" on that page). You also need to provide the following supporting documentation: CV, evidence of qualifications and evidence of English language (if applicable). You are welcome to include a covering letter. You don't need to provide a research proposal unless you are proposing your own project, or sample of academic written work. You will need to ask two referees to provide academic references for you – once you fill in their name on the form, they will be sent emails asking them to upload their references. Please note that we give serious consideration to both the stature of your referees and the remarks that they make about you. More details about the application procedure are given at <https://www.st-andrews.ac.uk/study/pg/apply/research/>

We look forward to hearing from you.