PhD Studentship in Optimisation/Statistics and River Infrastructure Planning

Ref: EPSRC DTA PhD Studentship

Applications are invited for a full-time PhD studentship in the area of Optimisation/Statistics and River Infrastructure Planning starting in September 2010. The studentship, which is supported through an EPSRC Doctoral Training Grant, will involve working on an interdisciplinary research project entitled “Next Generation Decision Planning Methods for River Infrastructure Placement and Mitigation” under the supervision of Dr Jesse O’Hanley. The main objective of the project is to develop novel optimisation and statistical models for prioritising river infrastructure removal and other mitigation activities, as well as identifying sites for future river infrastructure expansion, while taking into account a host of key environmental/ecological impacts (fish dispersal, habitat fragmentation, river hydrology and morphological processes) and socioeconomic impacts (fishing, recreation, water supply, flood control and hydropower generation). Multi-objective and stochastic integer programming techniques will be investigated together with Bayesian statistical modelling and exact/heuristic solution methods.

The PhD student will join the Management Science group within the Kent Business School. The Management Science group is one of the largest and top rated research groups in the UK. Further advanced training in operational research and statistics is available through the EPSRC’s NATCOR programme. As part of the project, the PhD will also have the opportunity to reside for up to one academic term in the US in order to work and study under the guidance of a leading academic (Prof Michael Kuby) from the School of Geographical Sciences and Urban Planning at Arizona State University, specialising in the field of optimisation and Geographic Information Systems (GIS) applied to transportation, energy, and environmental planning. Additional short-term visits to Scotland in order to work and liaise with the Scottish Environment Protection Agency, the main external project partner, may also be required.

The studentship covers Home/EU fees as well as provides a maintenance grant (approximately £13,500 p.a). Only UK and EU applicants are eligible to apply. The ideal candidate would normally be expected to hold a 2:1 or First class honours degree plus an MSc, or equivalently an upper 5-year undergraduate degree if coming from Europe, with a background in operational research, statistics, mathematics, computer science or some other quantitative discipline relating to the project. Excellent written and verbal communication skills are essential. Knowledge or experience in the use of one or more of the following is also highly desirable: optimization methods and algorithm design, CPLEX (or some other optimization package), computer programming (preferably C/C++ or Java), GIS, environmental economics, ecological/environmental modelling. Applications will be assessed based on previous academic achievements and relevant skills. Further information regarding the position is detailed below.

Project Summary:
The waterways of most industrialized countries, including the UK, maintain a high density of infrastructure (e.g., dams and weirs), reflecting a long legacy of extensive river modification and development. While on the one hand providing enormous economic and social benefits (e.g., water supply, flood control and hydropower), of major concern are the many adverse effects that in-stream structures have on the ecological integrity of rivers and catchments, including disruption of longitudinal and lateral water transfer, channel deterioration, habitat fragmentation and native species declines.

Nevertheless, there is an identified need to install additional infrastructure in UK rivers to monitor flows (as part of flood defence) and generate small-scale hydropower (to meet renewable energy targets). This, however, will inevitably create conflict with national and EU legislation (e.g., the EU Water Framework Directive), which will require significant public spending on the mitigation of new and existing structures in order to meet minimum environmental standards. The cost in England and Wales alone of retrofitting and removing known, high-impact barriers, which block fish dispersal, is estimated to exceed £540 million over the next 6 years.

Given the severity of this problem together with tight resources, the development of systematic planning methods will be essential for prioritizing barrier placement, removal and repair decisions. Although some initial attempts have been made in applying sophisticated optimization based techniques, current methodologies, nonetheless, still tend to be limited in scope and applicability. Models have generally been restricted to a narrow set of planning objectives (e.g., restoring access to salmon spawning grounds) and dependent on commonly invalid assumptions (e.g., access to complete and deterministic data). Greater consideration is needed for effectively coping with **risk** (e.g., the presence of unrecorded barriers and other input parameter uncertainties), while incorporating the importance of **key ecological/environmental processes** (e.g., population dynamics and hydrodynamics) together with balancing multiple, potentially competing, **environmental and economic goals** (e.g., fishing and hydropower generation). The current project will aim to address several of the key shortcomings in current knowledge and practice by developing, integrating and testing new optimization and statistical planning models for efficiently prioritizing river infrastructure removal decisions and other mitigation activities as well as future infrastructure development. By delivering on this goal, the project is highly relevant both from a basic research standpoint and equally important for its potential to improve the quality and effectiveness of real-world watershed planning and management.

Aims and Objectives
The primary aim of the research project will be to investigate the development of novel optimization models and solution techniques for cost-effectively prioritizing river infrastructure placement, removal and mitigation decisions. In line with these overarching aims, specific research objectives will be to investigate:

1. The development of new **multi-objective** methods for optimising river infrastructure removal and other mitigation activities, taking into account multiple positive and negative effects on fish and the wider aquatic community, river hydrology and morphological processes, and numerous other economic impacts including fishing, recreation, water supply, flood control and hydroelectric power generation.

2. The development of location planning tools for identifying sites for future river **infrastructure expansion** (e.g., hydropower generation and flood defences) while minimizing its associated negative environmental impacts on the amount, quality and connectivity of in-stream habitat as well as changes to sediment transport and river morphology.

3. The application and development of **risk based** planning tools (i.e., Bayesian statistical models and stochastic optimisation models) for prioritizing the removal and placement of in-stream barriers across a range of different planning scales given the persistent problem of having to deal with incomplete survey data, thus resulting in basic uncertainty as regards the exact number, location, passability, and repair cost of existing in-stream barriers.

4. The development and solution of barrier removal planning models which account for the importance of population dynamics via integration with spatially realistic, process-based fish **population models** that are driven by changes in the quantity, quality, and connectivity of in-stream habitat.

Impact:

The project, which will produce cutting-edge results at the interface between operational research and environmental science and management, will be aimed at designing new, highly robust methods and procedures for river infrastructure planning, which take into account the practical needs of real-world decision making. In this regard, the anticipated results of the research project will be of keen interest not only to other researchers in the field of river catchment management and planning, but also policy and decision makers responsible for watershed management and conservation. Given the urgent need to mitigate the negative ecological impacts of in-stream barriers, the project's research outputs will offer unmatched capabilities for helping managers to cost-effectively improve the ecological potential of heavily modified river systems, as required by recently enacted UK and EU legislation (e.g., Biodiversity Action Plans for UK priority species, the EU Water Framework Directive, and the EU Habitats Directive). Policy makers, in particular, are often hindered by a lack of useful techniques for river infrastructure planning.

As evidence to this, the project is being strongly supported by the *Scottish Environment Protection Agency* (SEPA). SEPA is the main public body responsible for protecting and improving the environmental quality of catchments in Scotland. In addition to furnishing access to essential geospatial data on river infrastructure and fish habitat, SEPA will provide independent, expert advice on a range of important issues such as case-study design and analyses and the development of decision support systems. Visits to SEPA by the PI and PhD student will be made on an as needs basis.

Engagement Activities:
Communication with academic beneficiaries will be an important priority. Research articles will be targeted at leading field journals together with presentations at top national and international conferences in the fields of environmental/fisheries management and operational research.

The project will also seek active engagement with UK environmental agencies and NGOs to ensure direct knowledge exchange with relevant stakeholders involved in fisheries and catchment planning. Collaboration with the Scottish Environment Protection Agency (SEPA), in particular, will help the research team to better understand and incorporate end-user requirements into final specifications of the modelling tools, carry out detailed discussion and direction of the research programme and help promote ownership of the project's outputs within partner organisations. This in turn will serve to help SEPA better understand the ways in which generated data and analyses can best inform policy, regulation or operational practice.

Further Skills Training:
Besides taking general and specialised classes taught within the Business School (e.g., statistics, optimisation and heuristic solution methods), the PhD student will also have access to relevant classes offered by the Durrell Institute of Conservation and Ecology (DICE) at the University of Kent within the areas of ecology and conservation planning. This will equip the PhD student with a unique set of skills in operational research and ecological/environmental sciences. The PhD's training will be further supported by:

1. **Postgraduate skills training**: Additional skill training and career development courses are offered by the Kent Graduate School and the EPSRC, covering areas related to personal/career development, communication (e.g., effective writing) and networking skills.
2. **NATCOR courses**: NATCOR is a programme run by the EPSRC, which offers short, intensive classes for PhD students on specialised methods in operational research and statistics. These mini-modules are taught by teams of leading academics at various campuses across the UK throughout the year. Topics in the past have included integer programming and cutting plane methods, stochastic programming, Bayesian statistical modelling and advanced state-of-the-art heuristic algorithms.
3. **External collaboration**: The PhD will gain valuable experience through collaboration with external academic and industrial partners, including an extended visit in year 2 to Arizona State University in the US (see below for more detail).

Overseas Visit:
It is intended that the PhD student will visit the US for one academic term (approximately 4 months) in year 2 to work under the close supervision of Prof Michael Kuby at Arizona State University (ASU). Prof Kuby is a leading academic in the field of location analysis applied to transportation, energy, and the environment planning, with special expertise in the development of multi-objective optimisation and GIS based decision support tools for sustainable infrastructure planning. He is also one of the few people working on the development of systematic planning tools for river infrastructure placement and mitigation. As such, the PhD student would benefit enormously from Prof Kuby's extensive knowledge in areas related directly to the project's overall research programme. Furthermore, the PhD student would also have the opportunity to gain additional research training by taking one or two specialised courses in physical geography, GIS modelling, statistics or operational research while in residence at ASU.

How to Apply:
Applications should be sent to:

Ms Claire Baldock
Research Secretary
Kent Business School
University of Kent
Canterbury, Kent
CT2 7PE

Tel 01227 823009
Email c.a.baldock@kent.ac.uk

quoting **EPSRC DTA PhD Studentship** in the email subject.

Applications should be sent electronically, including all of the following materials:

- A cover letter explaining your interest in the research project along with relevant training and skills appropriate to working on the project
- A curriculum vitae (CV)
- Official transcript(s) of your undergraduate/postgraduate degrees
- Names and contact information of two references (one of which must be from an academic institution you have studied at) who can supply letters of support if short-listed for the position
- Any English qualifications obtained if English is not your first language

Informal enquiries may be directed to the project's principal investigator:

Dr Jesse O'Hanley
Management Science Group
Kent Business School

Email j.ohanley@kent.ac.uk

Completed applications must be received no later than: 15 July 2010