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THE INFLUENCE OF AQUATIC VEGETATION ON FLOW IN LOWLAND RIVER

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Durham University, Department of Geography
In partnership with Centre for Ecology and Hydrology (CEH)

Supervisory Team

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Key Words Aquatic Vegetation, river modelling, flooding

Overview

The Summer 2007 flooding in England was the UK's largest peacetime emergency since World War II, with a cost of 13 lives and over £3 billion. The Pitt Review presented a comprehensive analysis of the 2007 flooding and the lessons to be learnt in managing future flood risk. The key observation relevant to this PhD proposal is that river corridor management practices, such as dredging and vegetation clearance were no longer performed as frequently, with the management focus shifting to flood control as an integrated part of river restoration and ecological integrity. The presence of vegetation within rivers has thus increased.

Vegetation within river channels has a profound influence on the functioning of the fluvial system. It can significantly increase local flow resistance and thus strongly reduce conveyance. This causes a reduction in flow velocity, which in turn leads to both positive and negative impacts, these include; i) higher water levels per unit discharge and therefore increasing the risk of flooding; ii) regions of reduced shear stress that promote sedimentation and; iii) contributes a positive influence on water quality by removing nutrients and producing oxygen in stagnant regions of the channel.

Given this and the complexity of flow-vegetation interactions, the representation of vegetation in either predictive equations of river flow or flood models is ineffective as it is commonly incorporated as a bulk roughness parameter. Current approaches use semi-empirical formulae to obtain a prediction of flow magnitude that parameterizes energy losses through a bulk friction parameter so as to reproduce the correct relationship between flow and water level. These parameters represent several processes that contribute to energy loss (e.g. momentum loss, dispersion associated with secondary circulation and diffusion) that cannot be measured directly, only estimated. As a result, a series of methods have been developed to aid the specification of roughness parameterisations. These include: i) look up tables where qualitative descriptors or photographs of the vegetation characteristics are assigned roughness parameters; ii) roughness parameterisations-flow correlations for different plant species, even though this may have no physical justification; and iii) empirical scaling relationships depending on the amount of vegetation in the channel. However, research has shown that even when such relationships are used, the value of roughness that is initially used may still not reproduce measured water levels and as such roughness parameters are optimized for future predictions. Consequently, there is still considerable uncertainty in the characterisation of vegetation-flow interaction which will hinder future management decisions related to river corridor management.

Recent work at both Durham University and the Centre for Ecology and Hydrology (CEH) has started to address this problem by the development of new numerical models (Figure 1). These have included the development of high resolution (cm scales) numerical models (Figure 1a) and the validation of these models through flume experiments (Figure 1b). However, this work needs to be extended to the scale of river reaches so that it can be effectively used in river corridor management. This requires the collection of field data (Figure 1c) and the development and application of new numerical models at a more practical resolution at the reach scale to predict flow in and around vegetation (Figure 1d).

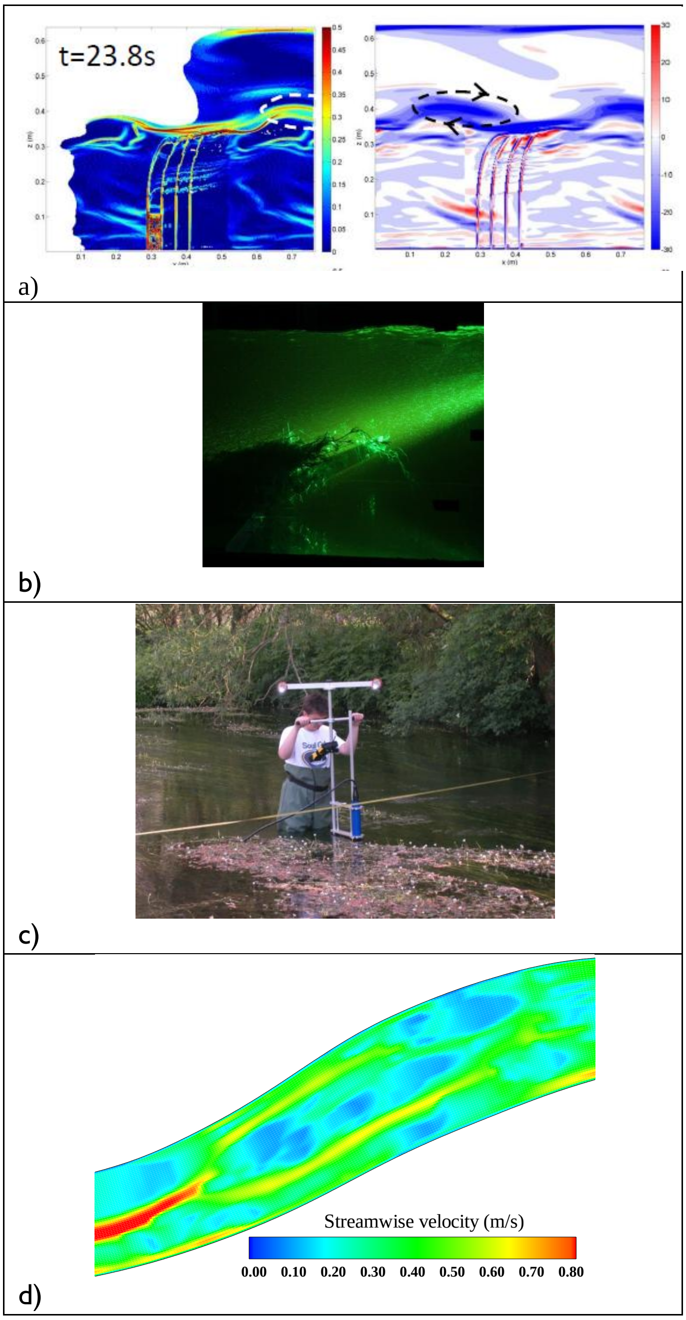

***Figure 1**: Example of ongoing work looking into flow vegetation interaction a) an example of a high resolution numerical model predicting turbulent structures being generated by plant stems; b) flume experiments to measure flow around aquatic plants; c) field data collection and; d) an example of incorporating predicting reach-scale flow in and around vegetation patches using a numerical model.*

Methodology

This proposed project seeks to improve the modelling of vegetation in a fluvial environment. The project will consist of;

1. The use of field survey and flow measurements to map and quantify the density of vegetation and its effect on flow. This will be undertaken on the CEH River Lambourn Observatory which has extensive in-channel vegetation (Figure 1c) and the River Browney, Durham.

2. New data collection relating to the movement of plants at both the scale of the whole plant and that of stems and leaves using novel photogrammetry techniques.

3. Development of a new numerical algorithm that considers vegetation as a moving boundary problem and application within an existing reach-scale model.

4. Validation of the numerical model against field data and consideration of river corridor management strategies for dealing with-in channel vegetation.

It is intended that the results of the project will provide quantitative understanding of the effect of vegetation on flood conveyance. This can be used to help predict future change in river dynamics and aid management decisions related to river corridor management.

Timeline

Year 1
1. *Field survey and data collection to quantify the effect of vegetation on flow. This will also include the collection of the necessary boundary conditions for a numerical model.*
2. *Develop an approach to measure the 4 dimensional (3D in space and time) movement of submerged vegetation.*

Year 2
1. *Field measurement and validation of plant movement.*
2. *Development of moving boundary numerical model.*

Year 3
1. *Validation of numerical model with field data*
2. *Develop management strategies of river corridor management based on process understanding gained from novel numerical model.*

Training & Skills

Training is fundamental to the development of postgraduate research students and, together with the DTP, University and Department we provide a substantial training programme. Priorities for training are determined from the 'Training Needs Analysis' carried out in the initial supervisory meeting with the student.

Departmental training in (a) research skills and techniques and (b) research environment are provided through four mechanisms: (i)a programme of taught modules; (ii) internal training 'workshops' that focus on key geographical research skills and techniques; (iii) input from supervisors; and (iv) departmental seminar by visiting and internal speakers and p

Physical geography research postgraduates normally take the taught departmental module 'Implementing Research Design' during their first year. The aim of this module is to help students put University training in research design into practice specifically in relation to physical geography research both generally and with regard to the student's own project work. Students receive instruction in data collection and the scientific method, contextualizing and problematizing research in physical geography, planning for field- and laboratory work, and team and group working in physical geography. Assessment of students in this module is formative. In addition to generic training offered by the University, the Department also provides training through a series of in-house 'workshops'. These workshops offer the opportunity to gain both experience and knowledge with a number of tools in a specifically geographical disciplinary context and to gain an understanding of some of the wider structures and practices which make up academic life. This programme has been developed in response to postgraduate requests and is open to ALL postgraduate students irrespective of degree or year of study.

Research training continues through the second and third years, and is based around a number of themes: Recognition and validation of problems; Demonstration of the original, independent and critical thinking, and the ability to develop theoretical concepts; Knowledge of recent advances within research field and in related areas; Understanding relevant research methodologies and techniques and their appropriate application within research field; Ability to analyse and critically evaluate findings and those of others; and Summarising, documenting, reporting and reflecting on progress.

References & Further Reading

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Further Information

Further information can be obtained from contacting Dr Rich Hardy.