Institution: University of Cambridge

Unit of Assessment: UoA17b

Title of case study: River and floodplain hydromorphology and ecology; co-production of research into best practice for river restoration

1. Summary of the impact (indicative maximum 100 words)

This case study concerns the impact of interdisciplinary research on policies and practices to support river restoration and the aims of the European Water Framework Directive (WFD), which requires member states to bring riverine hydromorphology and ecology to 'good' status by 2015, measured against a reference condition. The research achieved impact through an evolving process of co-production, in that academics engaged with user communities from the outset. **Richards, Hughes** and **Horn** (Department of Geography, University of Cambridge) worked closely with users to design a knowledge transfer guidebook to communicate restoration science to users.

This was distributed amongst Environment Agency (EA) staff to aid the planning and implementation of restoration projects. Further impacts included promoting floodplain restoration for flood risk management (**Richards**, as a member of an EA Regional Flood and Coastal Commitee); a rapid assessment method for river quality (**Richards** and **Horn**) that forms the basis of cross-boundary WFD compliance practices across the whole of Ireland; and knowledge transfer of EU WFD ecological assessment practices to China (**Richards**).

2. Underpinning research (indicative maximum 500 words)

Underpinning EU-funded research was conducted between 1996 and 2003 (Section 3a) into: (a) hydromorphology and the ecological health of rivers and their floodplains (relating to biodiversity gain); (b) impacts of riparian ecology on flood retention on floodplains (linked to flood risk management); and (c) characteristics of policies and institutions encouraging restoration, in circumstances where there is potential to combine both biodiversity gain and flood alleviation.

The most recent of these research projects was '**FLO**odplain **B**iodiversity **A**nd **R**estoration **2**: integrated natural science and socio-economic approaches to catchment flow management' (FLOBAR2; 2000-03, Section 3a). Keith **Richards** (Professor*, 1995-) was PI, Dr Francine **Hughes** was co-I (Senior Research Associate*, 1996-2003; now Reader, 2008-, Life Sciences, Anglia Ruskin University), and Dr Rachel **Horn** was Research Assistant* (2000-2003; now Civil and Structural Engineering, Sheffield University). (*all then in Geography, Univ. of Cambridge)

FLOBAR2's inter-disciplinarity was stressed by its PI (**Richards**) from the outset. For example, Minutes of the first FLOBAR2 Project Meeting (2000-05-11) state: "..the Work Package on institutional structures was concerned with the reflexive relationship between science and policy, and the guidelines to be produced for Work Package 1 would need to consider adaptations of scientific priorities to the institutional goals, as well as institutional changes as scientific understanding and needs develop." The project's structure also distinguished conventional "normal science" Work Packages (WP2 to WP7) from its stakeholder-engaged component (WP1). The scientific Work Packages dealt with aspects of floodplain vegetation and hydrology (WP2-WP6), while WP7 focused on the agencies that themselves manage restoration projects, and balance biodiversity gain and flood risk management purposes. These Work Packages were then enveloped within the "Mode 2 research" Work Package (WP1), which was co-produced with stakeholders in order to deliver practical research knowledge to users.

The research in WPs 2-5 examined how river and floodplain hydrology and geomorphology affect the germination, growth, dynamic evolution, and ecological and genetic diversity of vegetation on floodplains, especially woody species. This required field plot experiments, but also included innovative greenhouse experiments using "rhizopods" (soil columns) in which controlled lowering of the water-table was able to show the effects of water stress on riparian plants. These studies revealed how the species and age diversity of floodplain vegetation is negatively affected by flow management that limits recharge of floodplain groundwater, and thereby leads to the failure of seeds to germinate, and seedlings to mature. It also identified management strategies for enhancing ecological and genetic diversity and the biodiversity status of floodplain vegetation (see Section 3b for sample outputs of these research strands).

A further issue for floodplain restoration is that woody vegetation affects retention of stored floodwater on floodplains, by enhancing flow resistance and reducing floodplain flow rates. Floodwater retention attenuates downstream floods, which can be beneficial for urban areas; but if

retention is prolonged, storage available for a later flood is reduced. Thus, the effects of floodplain vegetation on flood retention must be carefully modelled, and its flow resistance must be understood. WP6 investigated these phenomena in laboratory and field experiments (the latter involving artificial floods on the River Wien, Vienna). It also led to a method for modelling vegetative roughness effects using LiDAR and 2D flow modelling (see Section 3c).

The institutional structures that balance these biodiversity and flood risk dimensions of floodplain restoration were the subject of social science research in WP7. Case studies revealed the problems of managing restoration projects involving multiple stakeholders with competing visions, objectives and funding streams (see Section 3d). Thus, the practical guidance document resulting from WP1 (see Section 3e) combined communication of scientific knowledge with material about institutional structures, capacities, strengths, and limitations.

As part of WP1, workshops were held involving key stakeholders [MAFF (Peter Allen-Williams), Environment Agency (Mark Diamond), River Restoration Centre (Nigel Holmes), Forestry Commission (Gary Kerr), English Nature (Keith Kirby), World Conservation Monitoring Centre (Christoph Zockler), RSPB (Russell Cryer); with representatives from France, Denmark, Croatia, Hungary and the US Department of Agriculture]. These workshops developed practical guidance for policy makers and river managers, focusing on the best way to present research findings for practitioners, and the key issues to emphasise in seeking to restore the natural functions of floodplains. The workshops produced the Mode 2 research output listed in Section 3e.

3. References to the research (indicative maximum of six references)

(a) Key Research Grants

- European Commission DGXII, Contract ENV4 - CT96-0317 (Project PL950283): Floodplain biodiversity and restoration: 1 Dec 1996-30 Nov 1999 (800k ecu). Awarded to **Richards**.
- European Commission DGXII Contract EVK1-CT-1999-00031; (Proposal No: EVK1-1999-00154) FLOBAR2: **FLO**odplain **B**iodiversity **A**nd **R**estoration **2**: integrated natural science and socio-economic approaches to catchment flow management.1 Mar 2000-28 Feb 2003 (1.477k euros). Awarded to **Richards**.

(b) Key References - Effects of river management on floodplain ecology

- Hughes F, Harris T, **Richards K**, et al. (1997) Woody riparian species response to different soil moisture conditions: laboratory experiments on Alnus incana (L.) Moench. *Global Ecology and Biogeography Letters* 6, 247-56
- **Richards, K**, Brasington, J & Hughes, F (2002) Geomorphic Dynamics of Floodplains: Ecological Implications and a Potential Modelling Strategy. *Freshwater Biology* 47, 559-579
- Xiong, S, Johannsson, M, Hughes, F, Hayes, A, **Richards, K** & Nilsson, C (2003) Interactive effects of soil moisture, vegetation canopy, plant litter and seeds on plant diversity in a British wetland community. *Journal of Ecology* 91, 976-986

(c) Key References - Effects of floodplain vegetation on floodplain flows

- Horn, R & **Richards, K** (2007) Modelling hydraulics in restored floodplain environments. In Wood, P, Hannah, DM and Sadler, JP (eds) *Hydroecology and Ecohydrology: Past, Present and Future*. John Wiley & Sons, Ltd, Chichester, 269-294
- Antonarakis, A, **Richards, K**, Brasington, J, Muller, E & Bithell, M (2008). Retrieval of vegetative fluid resistance terms for rigid stems using airborne lidar. *Journal of Geophysical Research* 113, G02S07, doi:10.1029/2007JG000543

(d) Key References - Policy and practice of restoration

- Hughes, F & **Richards, K** (2008) Floodplains in Europe: the case for restoration. Moss, T. (ed.) *Restoring Floodplains in Europe: Policy Contexts, Project Experiences*, IWA Publishing, 16-43

(e) Key Reference - Guidelines for river managers

- Hughes, F, **Richards, K** et al. (2004) *The Flooded Forest: Guidance for policy makers and river managers in Europe on the restoration of floodplain forests.* European Commission, 90pp. (Downloadable from http://www.geog.cam.ac.uk/research/projects/flobar2/)

4. Details of the impact (indicative maximum 750 words)

The path to impact has throughout involved a form of Mode 2 research (cf *Re-thinking Science* by Nowotny et al. 2001, Polity) in which researchers work with stakeholders to address 'real-world problems'. In this mode, relationships of knowledge, policy and practice involve iteration amongst

user communities and scientists, so that 'impact' becomes intimately bound up with research. **Richards** and **Hughes** worked iteratively with stakeholders throughout. The EA member of the Workshop group (Section 2) helped embed restoration objectives in UK flood risk policy (2004-9; see sub-section (ii) below); and **Richards** (2000-11) and **Hughes** (2004-09) participated in institutions responsible for enacting and implementing related policy (sub-section (ii) below), promoting the science leading to enhancement of river and floodplain environments.

This form of engagement has occurred at regional, national and international scales, leading to impacts with varying reach and significance.

(i) *Guidance for policy makers and river managers*

The Flooded Forest, the guidance document produced through WP1 of the FLOBAR2 project (Section 3e) was co-designed with Workshop stakeholder participants (section 2), and written by the research team. The pdf version has been downloaded over 9,000 times since 2004, and almost 3,000 times since 2008 (web-site data), with printed copies also distributed to the EA, SEPA and SNH, and many conservation bodies in the UK and Europe, at their request.

FLOBAR2 and *The Flooded Forest* were designed to support implementation of the WFD (and Dr H. Barth, the project's EC DGXII Senior Scientific Officer, confirms this intention). Mark Diamond (Ecosystems Manager, EA) found FLOBAR2 "inspirational", and EA staff distributed *The Flooded Forest* to those involved in WFD compliance and restoration; Ann Skinner (EA Senior Conservation Advisor), has stated: "I found *The Flooded Forest* to be an enormously interesting and helpful publication and I made sure all our Area teams were aware of it in support of the ongoing Wetland Vision project". Section 5(i) provides evidence of the pathway to impact resulting from the guidance document and its dissemination by the EA, in one subsequent example. First, Fran Southgate (Sussex Wildife Trust) notes "its value in supporting a variety of work on the restoration of floodplain woodlands in Sussex"; and Sandra Manning-Jones (Trees on the River Uck Project Officer) then provides evidence of its use in a project to plant trees on and adjacent to the floodplain of the River Uck in Sussex to create wet woodland for joint benefits of biodiversity and flood alleviation. This began in May 2012, and is on-going.

(ii) *Flood risk management and the Catchment Flood Management Plan (CFMP)*

The "win-win" potential of floodplain restoration for flood risk and biodiversity management, in suitable locations, is evident in the strategic Policy Option "6" (PO6) enshrined in EA CFMPs. This policy is adopted: "..where we [EA] will take action with others to store water or manage run-off in locations that provide *overall flood risk reduction or environmental benefits*."

Richards was appointed successively to the EA Great Ouse Local Flood Defence Committee (FDC), the Anglian (Central) Regional FDC, and the Anglian Central Regional Flood & Coastal Committee (2000-11). Over this period he actively supported the joint benefit of restoring natural floodplain function for flood risk management and biodiversity gain, through selection of PO6 where possible in the Great Ouse CFMP (published in 2011), and as the Regional FDC's representative on the CFMP Steering Group. PO6 is adopted along the Great Ouse River Corridor from Buckingham to Godmanchester, excluding the urban area of Bedford. This impact is validated in Section 5(ii) by Stephen Wheatley, the Regional FDC Chair, who observes: "..you were able to draw upon your research.. to successfully influence the adoption of a policy to restore floodplain and improve habitats for a large part of the Great Ouse River Corridor."

This direct engagement was matched by **Hughes**, who Chaired the National Trust's Wicken Fen Management Committee (2004-09) when its vision for expansion began to be realised through acquisition of land to re-naturalise a large area of the southern Fenland. This work was an impact of the research in section 2, and has generated additional, co-produced research and impact reported in an impact case study in an Anglia Ruskin University REF submission.

(iii) *Common approaches to river quality assessment (NS-Share)*

Richards and **Horn** acted as consultants to the NS-Share project (2004-2008) that developed common standards for implementing the WFD in the trans-boundary rivers of Northern Ireland and the Republic. Their proposed methodology for monitoring the hydro-morphology of rivers and floodplains adapted aspects of the US EPA Rapid BioAssessment Protocols, and field methods

complementary to those of the River Habitats Survey, to create a novel rapid assessment protocol (see Section 5(iii)). A continuing co-production of scientific impact then led to field testing and refinement of this "River Hydromorphology Assessment Technique", which still follows the framework proposed in the NS-Share project, and underpins the all-Ireland assessment methodology currently used for WFD compliance both pre- and post-restoration.

Mary Toland, Hydromorphologist at the NI Environment Agency states: "..the method you developed in the NS-Share project provides the framework for the all-Ireland assessment method for river hydromorphology for (WFD) reporting, and for both pre- and post- restoration monitoring... it is a recognised method also by Rivers Agency and the Office of Public Works who carry out flood prevention works in both the North and the South of Ireland." (see Section 5(iii).)

(iv) *International learning: Europe and China*

Richards has run four international workshops on River Basin Governance (RiBaGo; 2009-12), with a diverse range of academic and practitioner partners from Europe and China. This has acted as a forum for discussion of European (WFD) policies and practices for monitoring the hydromorphology and water quality of freshwater bodies, particularly in the context of Chinese interest in developing similar methods. Workshops have brought together members of European River Basin Commissions with counterparts in China (the Pearl and Yellow River Commission) to exchange views. These have complemented the activities of the EU-China River Basin Management Programme (RBMP), an EU-funded exchange programme; and a researcher (Andre Silveira; Cambridge, Geography) supervised by **Richards** has acted as rapporteur for the formal international exchanges. The contribution of the RiBaGo project to the EU-China RBMP is formalised in three of the Programme's internal papers, two of which are Reports on EU Missions to Chinese River Basin Commissions (see Section 5(iv)).

China's Ministry of Water Resources has developed guidelines on "Indicators, Standards and Methods for River Health Assessment" (2010), and is now testing these. **Richards** supervises participation in these tests by Mao Feng (Cambridge, Geography). An international learning process has thus developed from FLOBAR2, and continues its interaction of research, policy and impact. Simon Spooner, Technical Director, EU-China RBMP states that: "..ecological surveying in river health assessments has now been adopted as national policy in China to be implemented in all river basins by 2016, RBMP and RiBaGo were a part of building the momentum behind this decision." There has been "..direct influence to the policy and international cooperation process so enabling the research to have real and positive impact." (see Section 5(iv)).

5. Sources to corroborate the impact (indicative maximum of 10 references)
(Letters from stakeholders provide evidence of impacts discussed in Section 4.)

(i) Guidance for policy makers and river managers

Not included amongst the seven pieces of supporting evidence: E-mail from Ecosystems Manager, Environment Agency (e-mail dated 23-08-13); and letter from Senior Conservation Advisor, Environment Agency, Bristol (dated 18-06-13). Included to show pathway to impact are:

- Letter from person 1 (Wetlands Officer, Sussex Wildife Trust) (dated 15-07-13)
- Letter from person 2 (Trees on the River Uck Project Officer) (dated 09-07-13)

(ii) Flood risk management and the Catchment Flood Management Plan (CFMP)

- Letter from person 3 (Chair, Anglian (Central) Regional Flood and Coastal Committee) (dated 10-06-13)

(iii) Common approaches to river quality assessment (NS-Share)

- Original project documents are at http://www.nsshare.com/publications/ (follow links: Ecological Classification Tools > Hydromorphology Rivers and Lakes > Rivers)
- Letter from person 4 (Hydromorphologist, Northern Ireland Environment Agency) (dated 01-07-13)

(iv) International learning: Europe and China

- RiBaGo documents are at http://www.geog.cam.ac.uk/research/projects/ribago/, including Reports on the EU Missions to the Yellow River and the Yangtze River.
- Letter from person 5 (Technical Director, Atkins China Water & Environment) (dated 08-07-13)