Institution: Loughborough University

Unit of Assessment: C17 Geography, Environmental Studies and Archaeology

Title of case study: Transposition of European policy into practice: Conservation and management of riverine ecosystems

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

Research at Loughborough University (LU) from 2000-2013 by Dr Wood and Professor Wilby has enabled Natural England, the Environment Agency of England and Wales, and the Environmental Protection Agency of Ireland, to implement European Directives (Water Framework, Habitats, and Groundwater). Benefits were accrued from the development of monitoring techniques and integrated modelling to understand long-term drivers of ecological status in river systems. This research has been translated into field standards and planning guidelines within the UK water sector. Moreover, this work helped other organisations such as World Wildlife Fund (WWF-UK) to raise public awareness of the consequences of household water use on freshwater environments.

2. Underpinning research (indicative maximum 500 words)

Policies for managing and conserving freshwater ecosystems require scientific evidence to characterise the status of the environment (ranging from natural/semi-natural through to heavily modified water bodies). Geography at Loughborough University has a long tradition of applied research centred on the development and delivery of management objectives for freshwater ecosystems. Work undertaken by Professor Geoff Petts (1979-1993), and Professor Robert Wilby (left 1993, re-appointed 2008-present) **[3.1]** laid the foundations of current research themes and expertise within the Unit. These interests centre on field experimentation and characterisation of hydro-ecological and hydro-climatological data for managing and conserving freshwater ecosystems.

Since joining the Unit in 2000, Dr Paul Wood has undertaken research to characterise natural variability of macroinvertebrate communities inhabiting rivers (from drought to flood) to identify baseline (reference) conditions. Hydroecological analysis centred on the ecological consequences of flow variability and drought **[3.2, 3.3, G3.1]** was subsequently extended to a national scale dataset compiled by the Environment Agency of England and Wales in 2003 encompassing over 80 sites with long-term paired hydrological and ecological data **[3.4, G3.2]**. The detailed examination of this dataset was an essential test of the Environment Agency's LIFE (Lotic-invertebrate Index for Flow Evaluation) methodology for identifying instream invertebrate communities subject to river flow pressures (e.g., drought or excessive abstractions). This is the primary index used to characterise adverse river flow pressures on river-ecology across the UK for the EU Water Framework Directive **[G3.3]**.

After 2006, Dr Wood began to focus research on rivers impacted by abstraction of water for societal needs (domestic, agricultural and industrial). These rivers may be subject to significant pressures that can result in failure to obtain Good Ecological Status (GES) as defined by the EU Water Framework Directive due to reduced chemical and ecological quality of the river (water body). Dr Wood contributed to a series of national scale workshops between 2006-2013 to define and set standards for appropriate levels of water abstraction from rivers which have been adopted within UK water legislation **[3.5]**. The research also investigated how river flows that have been subject to significant modification (e.g., impoundment by dams) could be managed in the future to achieve Good Ecological Potential.

Other research undertaken by Dr Wood and Professor Wilby since 2008 included developing experimental and model frameworks for adapting freshwater ecosystems to climate change **[3.6]**; evaluating public water abstraction impacts on an EU Special Area of Conservation (SAC) **[G3.4]**; testing palaeoecological techniques to help deliver the EU Habitats Directive with Natural England through identification of reference conditions prior to river restoration measures **[G3.3]**; and providing baseline ecological data for groundwater dependent ecosystems to underpin the EU Groundwater Directive in the UK and Ireland **[G3.5]**.

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

Outputs based on research undertaken at Loughborough with evidence of quality [in brackets].

3.1. Large, A.R.G., Petts, G.E., **Wilby, R.L.** and Greenwood, M.T. 1993. Restoration of floodplains: a UK perspective. *European Water Pollution Control*, **3**, 44-53. [International, peer reviewed journal, Google Scholar citations = 7]

3.2. **Wood, P.J.** and Armitage, P.D. 2004. The response of the macroinvertebrate community to low-flow variability and supra-seasonal drought within a groundwater dominated river. *Archiv für Hydrobiologie.* **161**, 1-20. DOI: 10.1127/0003-9136/2004/0161-0001 [International, peer reviewed journal, WoS citations = 29]

3.3. Stubbington, R., **Wood, P.J.** and Boulton, A.J. 2009. Low flow controls on benthic and hyporheic macroinvertebrate assemblages during supra-seasonal drought. *Hydrological Processes*, **23**(15), 2252-2263. DOI: 10.1002/hyp.7290 [International, peer reviewed journal, WoS citations = 23]

3.4. Monk, W.A., **Wood, P.J**., Hannah, D.M. and Wilson, D.A. 2008. Macroinvertebrate community response to inter-annual and regional river flow regime dynamics. *River Research and Application*, **24**(7), 988-1001. DOI: 10.1002/rra.1120 [International, peer reviewed journal, WoS citations = 40]

3.5. Acreman, M., Dunbar, M., Hannaford, J., Mountfield O., **Wood, P.**, Holmes, N., Cowx, I., Noble, R., Extence C., Aldrick, J., King, J., Black A. and Crookall, D. 2008. Developing environmental standards for abstractions from UK rivers to implement the EU Water Framework Directive. *Hydrological Sciences Journal*, **53**(6), 1105-1120. DOI: 10.1623/hysj.53.6.1105 [International, peer reviewed journal, WoS citations = 16]

3.6. **Wilby, R.L.**, Fenn, C.R., **Wood, P.J.**, Timlett, R. and LeQuesne, T. 2011. Smart licensing and environmental flows: Modelling framework and sensitivity testing. *Water Resources Research*, **47**(12), W12524. DOI: 10.1029/2011WR011194 [International, peer reviewed journal, WoS citations = 1]

Grants (£'s given are for the allocation to Loughborough):

Code	*Dates*	***Title***	***Funder***	***Value***
G3.1	04/06-02/07	The response of aquatic invertebrate fauna to supra-seasonal drought and drying in a largely perennial chalk stream (PI-Wood)	NERC	£84,284
G3.2	04/08-04/11	The influence of hydromorphology on instream ecology (PI-Wood)	Environment Agency / CEH	£36,000
G3.3	10/08-04/12	Determining historic ecological conditions in lowland rivers: applying palaeoecological techniques to river restoration planning (PI-Wood)	NERC	£72,940
G3.4	10/08-12/08	Restoring flows to iconic rivers (PI-Wilby)	WWF-UK	£4,500

G3.5	01/08-12/11	Assessment of the distribution, structure and functioning of subterranean fauna within Irish groundwater systems (CI-Wood)	Environment Protection Agency (Ireland)	£2,595

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

Ratification of the EU Water Framework Directive (WFD) created opportunities for Dr Wood and Professor Wilby to interact with environment and conservation agencies in England, Scotland, Wales and Northern Ireland, as well as with the UK water industry. The following section outlines the significance and reach of their research and how it has contributed to the implementation and delivery of WFD legislation in practice.

In 2003 Dr Wood was granted access to a unique hydrological and ecological dataset (the Lotic-invertebrate Index for Flow Evaluation [LIFE] paired dataset) collected as part of monitoring programmes set up by the Environment Agency of England and Wales to examine macroinvertebrate community response to river flow regime variability **[5.1]**. This provided an opportunity to independently test the recently developed LIFE methodology and highlighted the potential to identify sites that could fail to meet Good Ecological Status (GES) as a result of river flow pressures. The outputs of this project have had significance internationally across the water sector with reach to environmental regulators and resource managers within water companies. This resulted in Dr Wood's participation in several national scale projects between 2006-2009 to develop environmental standards for water abstractions **[5.2]** and flow releases (environmental flows) from impounded rivers **[5.3]**. Dr Wood provided technical expertise in relation to macroinvertebrate community response to flow variability and abstraction pressures. These projects made recommendations to the UK Technical Advisory Group (TAG) responsible for coordinating implementation of the EU WFD which, following consultation with all UK responsible agencies, formed the basis of the adopted UK standards.

Since 2009 Dr Wood has been collaborating with Natural England to examine how rivers and sites with special conservation designations or supporting designated fauna (Sites of Special Scientific Interest or EU Habitats Directive designations) may be influenced by changes in flow regime. He applied palaeoecological techniques to define 'reference conditions' for EU WFD purposes in lowland rivers where little if any of the system remains un-impacted **[5.4]**.

Since 2010 Dr Wood has provided technical support to UK Water Industry Research (UKWIR) (2010-2011) to raise awareness, provide scientific evidence to underpin, and assist sector compliance with the EU WFD Good Ecological Status (GES) and Good Ecological Potential (GEP) for rivers subject to significant modification or impoundment (Heavily Modified Water Bodies - HMWB). This collaboration resulted in the development of an industry approved guidance document and interactive database for UK water companies and their regulators centred on identifying and assessing appropriate management actions to mitigate the ecological impacts of reservoirs **[5.5]**. Collaboration with Yorkshire Water (2011-2013) and Thames Water (2010-2013) identified how instream macroinverebrate communities respond to modification of the river flow regime associated with impoundment and abstraction for public water supply and how this may be mitigated to ensure compliance with GEP **[5.6, 5.7]**.

In 2006 the EU Groundwater Directive was adopted and for the first time highlighted the importance of groundwater dependent ecosystems when considering pollution of sub-surface water bodies. In 2008, Dr Wood joined a team led by the University of Ulster examining Irish groundwater biodiversity funded by the Environmental Protection Agency Ireland **[5.8]**. In June 2011 and December 2012 Dr Wood hosted workshops at Loughborough University under the auspices of the European Committee for Standardization (CEN) to develop international standards

to improve the consistency and quality of sampling of the hyporheic zone of rivers. The draft guidelines are currently passing through Europe-wide consultation prior to adoption.

Professor Wilby also provided technical advice on freshwater conservation and management from the river reach to catchment scale. For example, in 2008 the European Commission asked him to write the Executive Summary and substantial parts of their guidance on *River Basin Management in a Changing Climate* [presented in Brussels in January 2009]. The report was circulated to competent authorities in each Member State and explains how processes within the WFD could be used to strengthen resilience of freshwater ecosystems to climate change.

In 2008 Professor Wilby provided technical support to WWF's *Thames Vulnerability Assessment* which examined the potential impact of climate change alongside a host of other pressures on the health of the capital's river. In 2009 his analysis of long-term hydrometric data helped to shape WWF's public awareness campaign *Rivers on the Edge* **[5.9]** which explained the direct links between unfettered water demand and harm to river ecosystems. Likewise, in 2011 he advised WWF's *Itchen Initiative* which assessed the scope for 'smarter' licensing to better meet the water needs of both society and the environment under climate variability and change **[5.10]**. WWF used this document to inform Defra's 2011 White Paper and OFWAT's review of regulatory arrangements for the water industry in England and Wales.

In November 2011 Professor Wilby gave an invited speech about 'Adapting conservation science, and conservation organizations to climate change' to WWF's *50th Anniversary Fuller Symposium* at the National Geographic in Washington, DC. The event was transmitted by live webcast and attended by the general public, non-governmental organisations, schools and charities.

5. Sources to corroborate the impact (indicative maximum of 10 references)

The following sources of corroboration can be made available at request:

5.1. Environment Agency of England and Wales – Letter of corroboration (Environment Monitoring Team Leader).

5.2. SNIFFER (2006) WFD48- Development of Environmental Standards (Water Resources) – Stage 3: Environmental Standards. http://nora.nerc.ac.uk/3287/1/Stage3AcremanWFD48_2%5B1%5D.pdf

5.3. SNIFFER (2008) WFD82 – Guidance on Environmental Flow Releases from Impoundments to Implement the Water Framework Directive *http://www.wfduk.org/sites/default/files/Media/Guidance%20on%20flow%20releases%20from%20reservoirs%20final%20May%2007%20%20UPDATED%20COPY.pdf*

5.4. Natural England – Letter of corroboration (Senior Freshwater Ecologist).

5.5. UK Water Industry Research Ltd (2012) *Heavily Modified Waterbodies: Guidance Document* (12/WR/33/4). ISBN: 1 84057 641 3 *http://www.ukwir.org/report/94658/Reports/90179/Water-Resources/92951/Legislation/95092/Heavily-Modified-Water-Bodies:-Guidance-Document*

5.6. Cascade Consulting: Yorkshire Water – Heavily Modified Waterbodies Macroinvertebrate Report.

5.7. Cascade Consulting: Thames Water – Lower Thames Operating Agreement Report.

5.8. Biogeography and Ecology of Irish Groundwater Fauna (EPA STRIVE 2007-W-MS-1-S1). *http://www.epa.ie/pubs/reports/research/water/STRIVE_95_web.pdf*

5.9. WWF *Rivers on the Edge*. http://assets.wwf.org.uk/downloads/rivers_on_the_edge.pdf

5.10. WWF *Itchen Initiative*: http://assets.wwf.org.uk/downloads/itchen_initiative_executive_summary.pdf