Institution: University of Ulster

Unit of Assessment: 7 Earth Systems and Environmental Sciences

Title of case study: Changing Water Policy in the Republic of Ireland

1. Summary of the impact

Research undertaken by Professor Phil Jordan on nutrient pollution from land to waters has led to significant changes in government policy and in expectations for Water Framework Directive (WFD) and Waste Directive (WD) compliance in Ireland. The WFD is European wide legislation requiring that all water-bodies should be of at least good ecological status by 2015. His research has provided unequivocal scientific evidence that bio-physical lag times preclude the achievement of WFD water quality targets from diffuse source pollution by 2015. This has led to targets for good water quality in all River Basin Management Plans being extended without threat of European fines. Further, inclusion of Jordan's research on the specific environmental risk of rural point source pollution in assessments of septic tank system risk has resulted in the overturning of a European Court ruling under the Waste Directive, and the consequent lifting of daily fines of €19,000.

2. Underpinning research

Since being appointed as a lecturer at the University of Ulster in 2001, Professor Phil Jordan's research has specifically focused on the history, processes and policies of nutrient (nitrogen and phosphorus) pollution in rural catchments and the freshwater eutrophication process.

Palaeolimnological work in the Oona Water tributary of the Irish cross-border Blackwater River (Jordan et al., 2001) demonstrated that a modern conceptual model of soil phosphorus accumulation, transfer and pollution was valid over a c.100 year period; and the rate of historical lake eutrophication was the same at the small (c.1km^2) lake catchment scale as the very large Lough Neagh (c.5,000 km^2) lake catchment scale in Northern Ireland.

This work in the Oona Water catchment was further augmented with the NERC funded "Catchment Hydrology and Sustainable Management (CHASM)" infrastructure project and the Irish Environmental Protection Agency funded "Eutrophication from Agriculture Sources" project, a conceptual framework for both diffuse and point source nutrient pollution in soils of low permeability which was developed to inform government on eutrophication mitigation strategies.

As a direct development of this research, in 2004 Prof Jordan led the EU INTERREG IIIa funded Blackwater TRACE (Trans-boundary River-basin Action for Community and Environment) project which sought to test the efficacy of emerging and proposed WFD mitigation measures. The project collected high resolution chemical water quality data sets in three small (3-5 km^2) grassland agricultural sub-catchments and developed a bankside analyser instrumentation suite from equipment which had formerly been used in water treatment plants. This novel approach revolutionised bankside water sampling (Jordan et al., 2007) as, for the first time, long term high resolution (sub-hourly) water quality data sets could be collected, synchronous with river discharge. These data were subsequently used to test theories of river chemistry monitoring from less frequent data and to evaluate the use of new technology passive samplers (Jordan et al., 2013).

The technique of high resolution nutrient monitoring in rivers has since been emulated in a number of high profile catchment studies (e.g. the Irish Agricultural Catchments Programme, the UK Demonstration Tests Catchments, and the North Wyke Farm Platform).

Blackwater TRACE included specific research into reducing phosphorus from excessively fertilised soils and replacing defective septic tank systems; the high resolution monitoring demonstrated pressures from these sources at both high and low river discharges. The results clearly showed that soil phosphorus declines would be slow to achieve in the impermeable soils near the Blackwater River and would not necessarily be mirrored by synchronous changes in phosphorus concentrations during diffuse high flows in rivers. Through additional research, the results also demonstrated that replacing defective septic tank systems would only be successful if a planning strategy to avoid clusters (i.e. increased densities) in headwater systems was developed (Macintosh et al., 2011) – otherwise septic tanks would continue to be an environmental risk to the on-going eutrophication of headwaters during low summer flows in Ireland and elsewhere (Arnscheidt et al., 2007).

These themes were continued and augmented by Prof Jordan during a three year secondment period as Principal Scientist to Teagasc, the Irish Agriculture and Food Development Authority (01/01/09 to 31/12/11). In one study during this period, the decline of excessive soil phosphorus was modelled to predict the time taken to reduce to an agronomic optimum under fertiliser deficit scenarios – and so become environmentally benign to diffuse pollution (Schulte et al., 2010). Here, lag-time scenarios of 7-20+ years were predicted, independent of soil type, and this validated the work in the Blackwater River catchment. In a partner study, a groundwater model of nitrate-nitrogen flux was developed to show how there was also a lag-time associated with high nitrate concentrations leaving a polluted aquifer and that this was dependent on metrics of soil permeability and on the geology controlling both vertical and lateral nitrate fluxes (Fenton et al., 2011).

During the secondment period the number of high resolution nutrient monitoring stations in Ireland was increased from three to nine in order to investigate diffuse and point source pollution processes across a land-use gradient. Soil controls on diffuse pollution were validated in multiple soil types (Jordan et al., 2012) and the impacts of septic tank systems were reproduced. The techniques have also been used for the first time to investigate nutrient fluxes from karst springs and this on-going research has developed theories of critical source areas of diffuse P pollution in karst landscapes.

3. References to the research (* identify those that best indicate the quality of the work)

***1. Jordan, P.,** Arnscheidt, Joerg, McGrogan, H. and McCormick, S. (2007) Characterising phosphorus transfers in rural catchments using a continuous bank-side analyser. HYDROLOGY AND EARTH SYSTEM SCIENCES, 11 (1). pp. 372-381.

***2**. Schulte, R. P. O., Melland, A. R., Fenton, O., Herlihy, M., Richards, K. and **Jordan, P**. (2010) *Modelling soil phosphorus decline: Expectations of Water Framework Directive policies*. ENVIRONMENTAL SCIENCE & POLICY, 13 (6). pp. 472-484.

***3.** Fenton, O, Schulte, RPO, **Jordan, P**., Lalor, STJ and Richards, KG (2011) Time lag: a methodology for the estimation of vertical and horizontal travel and flushing timescales to nitrate threshold concentrations in Irish aquifers. ENVIRONMENTAL SCIENCE & POLICY, 14. pp. 419-431.

4. Arnscheidt, J., **Jordan, P.,** Li, S., McCormick, S., McFaul, R., McGrogan, H. J., Neal, M. and Sims, J. T. (2007) *Defining the sources of low-flow phosphorus transfers in complex catchments.* SCIENCE OF THE TOTAL ENVIRONMENT, 382 (1). pp. 1-13.

5. Jordan, P., Cassidy, R., Macintosh, K.A. and Arnscheidt, J. (2013) Field and Laboratory Tests of Flow-Proportional Passive Samplers for Determining Average Phosphorus and Nitrogen Concentration in Rivers. ENVIRONMENTAL SCIENCE & TECHNOLOGY, 47 (5). pp. 2331-2338.

6. Jordan, P., Melland, A.R., Mellander, P.-E., Shortle, G. and Wall, D. (2012) The seasonality of phosphorus transfers from land to water: Implications for trophic impacts and policy evaluation. SCIENCE OF THE TOTAL ENVIRONMENT, 434. pp. 101-109.

7. Jordan, P., Rippey, B. and Anderson, N.J. (2001) Modelling diffuse phosphorus loads from land to freshwater using the sedimentary record. ENVIRONMENTAL SCIENCE & TECHNOLOGY, 35 (5). pp. 815-819.

8. Macintosh, K.A, **Jordan, P.,** Cassidy, R., Arnscheidt, J. and Ward, C. (2011) Low flow water quality in rivers; septic tank systems and high-resolution phosphorus signals. SCIENCE OF THE TOTAL ENVIRONMENT, 412 . pp. 58-65.

Key Grants

"Catchment Hydrology and Sustainable Management" (2000-2005), Natural Environment Research Council. (£215,488)

"Eutrophication from Agriculture – Soil and Phosphorus (Catchment Studies)" (2000-2004), Environmental Protection Agency ERTDI. (£131,458)

"Blackwater Trans-boundary River-basin Action for Community and Environment (TRACE)" (2004-2008), INTERREG IIIA. (£1,457,999)

"Testing a New Technology for Monitoring Nutrients in Rivers" (2008-2010), Environmental Protection Agency STRIVE. (£176,263)

"An **E**ffective **F**ramework **F**or assessing aquatic **EC**osys**T**em responses to implementation of the Phosphorous Regulations (**EFFECT**)" (2008-2011), Environmental Protection Agency STRIVE. (£20,091)

4. Details of the impact

Two policy impacts related to the Republic of Ireland's obligations under the EU Water Framework Directive (WFD) and Waste Directive (WD) resulted from this research; achieving at least good ecological status in water bodies by 2015 and providing a strategy for mitigating septic tank system pollution. Respectively:

In 2009 the Irish Government approached Teagasc to provide a scientific assessment of the bio-physical lag-times associated with soil phosphorus decline and nitrate enrichment of groundwaters in agricultural catchments. Due to his experience with nutrient transfer science, Prof Jordan was asked by Teagasc (during his secondment period) to investigate these processes and assess the potential of the River Basin Management Plans in Ireland to meet the goals of the WFD and achieve at least good ecological water status by 2015.

The results showed that, while the measures to mitigate excessive phosphorus in soils and nitrate enrichment of groundwaters were sound, there were bio-physical constraints that would ultimately hinder water quality measures to be met in the time specified. The original measures could achieve the targets set by the WFD but only if sufficient time were allowed to accrue between implementation and compliance.

Specifically, the soil phosphorus decline model developed by the team at Teagasc, based on realistic farm management scenarios, estimated that improvements in soil phosphorus status to meet the requirements of the WFD may take up to 20 years (Schulte et al., 2010); longer than anticipated and beyond the original target deadline of 2015 for achieving at least good water quality status. In addition, the groundwater quality models and simulations developed by Fenton et al. (2011) suggested that acceptable nitrate concentrations would only be achieved between 2019 and 2033, if mitigation were implemented by 2012.

These findings provided further evidence for a more phased time frame for compliance with the WFD water quality targets and as a direct result, and following consultation with the EU, all River Basin Management Plan targets were amended to account for revised lag-times – up to 2027 for achieving 100% good status[1,2]. The work has greatly benefitted the Irish Department of Environment, Community and Local Government which has overall administrative responsibility for WFD compliance via individual River Basin Districts[3]. Without coherent mitigation measures in place and a scientific assessment of the likelihood of these measures to correct water quality impairment by the 2015 target date, Ireland would have been at risk of investigation and charge by the European Court.

Further, as a consequence of a European Court order under the WD on a water quality infringement resulting from the poor regulation of septic tank systems, the Irish Environmental Protection Agency (EPA) has introduced a process of registration, inspection and mitigation works in rural areas. Previously, pathogenic contamination of groundwater from faecal matter in 25.4% of water samples was referred to the European Court of Justice resulting in a lump sum fine of €1,8m and a daily penalty payment of €19k until the infringement ended. Research led by Prof Jordan identified the environmental risk to surface waters from low level persistent effluent discharges especially in areas with high septic system density and low soil permeability (Arnscheidt et al., 2007; Macintosh et al., 2011). This research was recognised by EPA hydrometric and ecology sections and a revised inspection plan now includes a methodology to include environmental (as well as health) risk to both ground and surface waters[4,5]. Daily EU fines were lifted on the 12th February 2012, the same day publication of these risk assessments contained in the National inspection plan were adopted[6].

5. Sources to corroborate the impact

[1] Final River Basin Management Plan. Background Documentation. Alternative Objectives: Approach to extended deadlines. (Pages 9, 11, 28, and 40.)

[2] Shannon Integrated River Basin Management Plan (2009-2015) Incorporating Amendments for the Ministry of The Environment, Heritage and Local Government. (Pages 36, 37, and 82.)

[3] Statement from Water Inspector, Department of Environment, Community and Local Government.

[4] http://www.epa.ie/pubs/reports/water/wastewater/EPA_DWWTS_RiskRanking.pdf. (page 28.)

[5] Statement from Manager, Hydrometric and Groundwater Programme, Environmental Protection Agency.

[6] Statement from Scientific Officer, Groundwater Section, Environmental Protection Agency.