

PROFESSOR GEOFFREY PETTS (1953-2018): AN OUTSTANDING INTERDISCIPLINARY RIVER SCIENTIST

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ABSTRACT

This paper provides an introduction and an editorial to this special issue of *River Research and Applications* by documenting the contributions made by Professor Geoffrey Petts to our interdisciplinary understanding of the functioning of rivers and their floodplains and their sustainable management.

We outline Geoff's career, which framed not only his research but its communication through his inspirational teaching but also included very high level and innovative contributions to the management and development of several UK universities.

We then explain how and why Geoff was an outstanding interdisciplinary river scientist and how he communicated his science through both integrative books and book chapters and also research papers that developed eight complementary research themes.

Lastly we introduce the papers in this special issue and show how they provide inputs to all eight of Geoff's areas of research interest.

KEY WORDS

Professor Geoffrey Petts, River Science, River Management, Interdisciplinary

INTRODUCTION

This Special Issue of *River Research and Applications* is presented in memory of Geoff Petts and complements the virtual special issue, which represents a selection of Geoff Petts' research papers originally published in *River Research and Applications*, *Earth Surface Processes and Landforms*, *Hydrological Processes*, *Aquatic Conservation* and *Freshwater Biology* between 1984 and 2015. The virtual special issue was dedicated to:

'Geoff Petts – vice chancellor, professor, river scientist, teacher, colleague and friend, whose inspiration and fortitude in bringing together the many elements fundamental to our understanding of river science have been a platform for many; without his visionary ideas river science would not be as advanced as it is today'.

In this extended editorial, we hope to provide a broad background that expands on and complements this dedication.

Geoff was the founding editor of *River Research and Applications* (originally *Regulated Rivers: Research & Management*) and was editor in chief for the first 32 volumes (1986-2016, inclusive). This achievement is all the more amazing given his own prolific research outputs (a full bibliography including the papers cited in this introduction are listed below), and the fact that he also worked as a

full-time academic teacher and administrator from 1978 to 2017, culminating in highly demanding, senior university management roles including over a decade as Vice Chancellor and President of the University of Westminster, London.

Geoff was a brilliant, innovative and charismatic teacher and speaker who inspired generations of river scientists, including many who now occupy senior research and academic teaching posts worldwide. In his teaching at all academic levels he was both a leader and team player, translating ideas into practice while at the same time ensuring that the learning process was inspiring and fun. He applied these same abilities with outstanding success in his many administrative roles. However, in future decades he will be most widely remembered for his scientific contributions. These have had major impacts on the development of river science over the last half a century and have been paralleled and perfectly illustrated by the development and contents of *River Research and Applications*.

CAREER

Geoff's academic career commenced with entry to a joint Geography and Geology honours degree programme (1971-1974) at the University of Liverpool, following his school education at Ashford Grammar School. He went on to study for a PhD, initially at the University of Exeter (1974-1976) and then the University of Southampton (1976-1977, PhD awarded 1978), under the supervision of Ken Gregory. His PhD thesis, entitled 'The adjustment of river channel capacity downstream from reservoirs in Great Britain', provided the starting point for his research career in river science and his realisation that understanding and managing rivers depends upon the truly interdisciplinary approach that is elaborated in the next section of this introductory paper.

Geoff's first lecturing post was at the Dorset Institute of Higher Education (1977-1979). In 1979 he was appointed to the University of Loughborough, where he was promoted to Professor in 1989 and was Head of the Geography Department from 1990 to 1994. In 1994, he moved to a professorial post at the University of Birmingham. He was appointed Director of the Centre for Environmental Research and Training (1994-2007) to promote interdisciplinary activity and a partnership culture between the University and the user community, enabling the University to be more proactive in meeting the emerging environmental research needs of industry. He also served as Head of the School of Geography and Environmental Sciences (1998-2001) and Pro Vice Chancellor (2001-2007).

In 2007, Geoff was appointed Vice Chancellor and President of the University of Westminster, London. During his time at Westminster University (2007-2017) he took on many external administrative roles including Chair of the Ratings Group of Universities UK (2010-2017), leading delivery of Framework Agreements (2012 and 2017) with the Valuation Office Agency; Chair of the Board of Podium (2010-2013), responsible for engaging and co-ordinating support from Universities and Further Education Colleges across the UK for the London 2012 Olympic Games; and he was elected Chair of the Board of Trustees of London Higher (2014-2018).

His academic achievements were recognised through the award of the Busk Medal of the Royal Geographical Society, 2007, for contributions to interdisciplinary research on river conservation. In conferring the award the President commended the way in which he had forged interdisciplinary links between geographers, civil engineers, biologists, ecologists and conservationists. He played a huge role in the formulation, development and life of the International Society for River Science which was launched in 2006, serving as President (2011-2013), and receiving their Lifetime Achievement Award in 2009. He was elected President of the British Hydrological Society (2015-2017), organising the 13th BHS National Symposium (2018), even though he sadly died a few weeks

before the conference took place. He was appointed Honorary Professor at the University of Uzbekistan (2008), Beijing Normal University (2010), Queen Mary University of London (2017) and he was awarded an Honorary DSc from the University of Westminster (2018). This brief overview of Geoff's career not only illustrates his enormous achievements but the fact that he was extremely active to the end of his life.

INTERDISCIPLINARY RIVER SCIENCE

Disciplines as branches of learning or scholarly investigation are the traditional architectural components for organisational and research frameworks in higher education. However, certain areas such as river research need to transcend traditional disciplinary boundaries. Geoff was pioneering in achieving the necessary fusion and implementation of an interdisciplinary approach to river science and management.

Multidisciplinary and interdisciplinary approaches are now accepted as essential in most contemporary research. However, this was not the case when Geoff commenced his career and is why his many contributions, which have focused on and significantly advanced these approaches, have been so crucial to the development of river science.

Multidisciplinary (first used 1942) and interdisciplinary (first used 1926) are often used interchangeably (Merriam-Webster on-line dictionary, <https://merriam-webster.com>, retrieved 19 July 2019). Whereas multidisciplinary involves several subjects of study in one activity, interdisciplinary goes further and combines elements of two or more disciplines. When he began his research, Geoff was perhaps naturally inclined towards a multidisciplinary approach because his first degree was in both Geography and Geology at a time when a single honours degree was a more typical background for research students. A multidisciplinary approach in his doctoral research and early research publications is evident in the textbook *Rivers and Landscape* (1985), which he wrote with Ian Foster. This was a landmark text which brought a multidisciplinary perspective on rivers to a generation of undergraduate students. However, his first book *Impounded Rivers*, subtitled *Perspectives for Ecological Management*, published in 1984 in a series of Environmental Monographs edited by Nicholas Polunin, provided a truly interdisciplinary perspective. It presented the cascade of first order (flow regime, water quality, sediment load, periphyton), second order (channel form and substrate, plankton, macrophytes) and third order (invertebrates, fish) impacts of impoundments on river ecosystems, and illustrated how these impacts and controlling processes interacted through time and across space. By explicitly linking traditional disciplines through a process cascade, he demonstrated the need for an interdisciplinary perspective that could interweave knowledge from multiple disciplines into an integrated approach to river management problems and prospects.

Geoff's progress in developing such an interdisciplinary approach was demonstrated in the establishment of the journal *Regulated Rivers: Research & Management* in 1986, which was 'dedicated to the promotion of interdisciplinary research concerned directly or indirectly with river management'. Geoff was founding Editor-in-Chief, and he was supported by two zoologists as regional editors and an editorial board of 16 whose backgrounds exemplified the interdisciplinary focus of the journal. As the readership of the journal grew it was refocused in 2002 to reflect its growing interdisciplinary and applied status to become *River Research and Applications*.

The developing interdisciplinary approach that Geoff promoted is also evident in the more than 25 books that he wrote and edited. This interdisciplinarity is as evident in *Historical Change of Large Alluvial Rivers: Western Europe* (Petts, Möller and Roux, 1989) as in the special issue of *Regulated*

Rivers titled *River regulation in the United Kingdom* (Petts and Wood, 1988), and the edited books *The Rivers Handbook* Volume I (Calow and Petts, 1992), Volume II (Petts and Calow, 1994), and *Fluvial Hydrosystems* (Petts and Amoros, 1996). Stressing the need for development of environmentally sound river management and regulation, *River Conservation and Management* (Boon, Calow and Petts, 1992) aspired to convey the current scientific understanding and also to be 'a signpost for future development in this complex, multi-disciplinary area'. *Global Perspectives on River Conservation* (Boon, Davies and Petts, 2000) was described as 'the first book that provides a truly global synthesis of knowledge on river conservation with the aim of encouraging strategic river planning', demonstrating that interdisciplinary does not just fuse academic disciplines but also engages a range of participants including river managers, planners and developers, conservationists and government departments. Appreciating that for certain subjects some social history is a necessary inclusion in an interdisciplinary approach, *Urban Rivers: Our Inheritance and Future* (Petts, Heathcote and Martin, 2002) was specifically written to be accessible to a broad audience to demonstrate the effects of urbanisation on the aquatic environment; potential solutions to the resulting problems; and new opportunities for the regeneration of urban streams and rivers. This highly accessible book is yet another example of the way Geoff conveyed complex interdisciplinary science concepts to make them easily accessible to undergraduate students and more generally to non-specialists.

Almost all of Geoff's research papers focused on interdisciplinarity and management implications but usually also highlighted a particular central theme. The themes that he explored varied widely and evolved over his career, often reflecting collaborations that he established with numerous scientists across a range of disciplines and from many different countries. These resulted in an impressive list of, frequently co-authored, publications. The next section highlights some of these themes.

RESEARCH THEMES

Geoff's earliest papers drew on his PhD research, focussing on river channel changes downstream from dams (theme 1). These papers followed an increasingly interdisciplinary perspective throughout Geoff's entire academic career, commencing with the concept of complex geomorphological response to changes in flow and sediment transport regimes (Petts, 1979, 1980b, 1982, Petts and Lewin, 1979, Petts and Pratts, 1983) over different temporal and spatial scales (Petts, 1980c) and their implications for river habitats (Petts, 1980a; Petts and Greenwood, 1981, 1985). He soon moved on to more detailed work on the impacts of dams on river ecology as he developed research collaborations with aquatic ecologists (Petts et al, 1993, Castella et al, 1995, Greenwood et al., 1999) and this research led to consideration of other themes outlined and discussed below. Throughout his career, Geoff kept returning to this theme, particularly to provide up-to-date reviews of the subject (e.g. Petts and Gurnell, 2005, 2013).

Perhaps the theme with which Geoff was most closely associated, and for which he will be most remembered, can be summarised as 'river flows and flow regimes: natural variability, human manipulation, and flow allocation to protect river ecosystems' (theme 2). Early in his career, he focused on the pervasive effects of river regulation activities and their long history, particularly in Europe (Petts 1987, 1988). He went on to examine and emphasise the ecological impacts of changes in river flows associated with flow extremes and surface-groundwater interactions (Wood and Petts, 1994, 1999; Wood et al., 1999, 2000; Grapes et al., 2005, 2006) and caused by surface water (Armitage and Petts, 1992, Petts and Bickerton, 1994) and groundwater (Bickerton et al., 1993) abstractions. This led to more formal approaches to flow regime classification (Harris et al., 2000), the characterisation of flow variability (Wood et al., 2001a,b), and an increasing emphasis on ways of

assessing flow regime alterations and determining how flow could be beneficially allocated to protect river ecosystems (Petts, 1996, 2001, 2017; Petts et al., 1999, 2006a,b, 2009; Clifford et al., 2002; Naiman et al, 2002; Jones and Petts, 2006; Yin et al., 2011, 2012, 2014, 2015a,b, Yarnell et al., 2015). He called this research 'instream flow science' and returned to review the topic on numerous occasions in book chapters (Higgs and Petts, 1988; Petts and Maddock, 1994; Petts et al., 1995; 2007; Gurnell and Petts, 2011), most recently publishing papers that review the early pioneering work of George Baxter (Neachell and Petts, 2017, 2019 – in this volume).

In parallel with river flows, Geoff was fascinated by river water quality and its management (theme 3). Initially he focused on water quality characteristics of regulated rivers (Petts, 1986; Foulger and Petts, 1985, Petts et al, 1985, 2000; Gilvear and Petts, 1985; Petts and Thoms, 1986), particularly emphasising mineral sediments in association with depositional landform development (Steiger et al., 2001; Petts and Thoms, 1987; Shi et al., 1999; Gurnell et al., 2008) and infiltration and clogging of the river bed (Petts, 1984, 1988; Milan et al., 2000). He also published methodological papers on freeze-coring and other means of characterising and quantifying fine sediment accumulation in river beds (Petts et al., 1989, 1991; Harper et al., 2017), and on flow manipulations to flush fine sediments and their ecological implications (Espa et al., 2015). Although much of his water quality research was concerned with fine sediment, he also considered water and temperature exchanges across and within river beds (Evans et al., 1995, 1997, 1998).

As an expression of the issues raised by environmental change, theme 4 in Geoff's research interests concerned alpine and glacial river systems, emphasising their hydrology, geomorphology, ecology and sensitivity to change. Following a conceptual paper on the physical habitats and ecology (Milner and Petts, 1994), he reviewed how their physical characteristics (Smith et al., 2001) and macroinvertebrate community structure responded to environmental conditions (Milner et al., 2001) and their sensitivity and response to climate change and human impacts (McGregor et al., 1995; Gurnell et al., 2000; Hannah et al., 2007). His work on one alpine river, the river Tagliamento in NE Italy, provides a direct link with research on riparian vegetation and large wood in river dynamics (theme 5).

Although Geoff published papers on many river and floodplain organisms including invertebrates (Greenwood et al., 1991, 1995a,b, 2001; Bell et al., 1999) and fish (Petts et al., 1989; Gosselin et al., 2010, 2012; Petts et al., 2015), he made his most important contributions in relation to vegetation, particularly the role riparian trees and wood in 'engineering' river channels (theme 5). Indeed, as his work on theme 1 evolved, he incorporated vegetation as a major influence on river channel adjustment downstream from dams (Petts and Gurnell, 2013). Early work on large wood (Gurnell et al., 1995) led to several decades of research on the Tagliamento river, where interactions between living trees, dead and living large wood, river flows and sediment transport revealed the fundamental impact of vegetation on the morphodynamics of this large alpine river (Edwards et al., 1999; Gurnell et al., 1999, 2000a,b, 2001, 2005; Ward et al., 1999, 2000; Gurnell and Petts, 2002, 2006; Karrenberg et al., 2003; Tockner et al., 2003, Francis et al., 2005, 2006, 2008). In parallel to this research on the Tagliamento, Geoff conducted more general research on riparian vegetation and also on the biodiversity and biogeochemistry of rivers and floodplains. Some of this work was broadly-based and conceptual (Petts, 1997; Decamps et al., 2004; Pinay et al., 2007) and some focused on specific rivers or biogeographical regions (e.g. Rosales et al., 1999, 2001, 2002).

In contrast to the dynamic, near-natural environment of the Tagliamento, Geoff was also concerned with the management and restoration of urban rivers (theme 6). This holistic perspective (Petts et al., 2002) included issues of flood risk (Webster et al., 2001), sediment (Lawler et al., 2006) and rehabilitation potential (Boitsidis et al., 2006). He was also concerned with sustainable restoration of

ivers and their floodplains whether they were located within the city or beyond (Large et al., 1993; Gurnell et al., 2006).

While Geoff was primarily a field scientist, he had an enormous interest in historical maps, archives and books. He published books (Petts et al., 1989), book chapters (Petts, 1990; Gurnell et al., 2003) and papers (Large and Petts, 1996) that concerned the analysis of historical sources to investigate river and floodplain change, and particularly to establish the physical impacts of river engineering and water resource development. Therefore, theme 7 can be summarised as ‘historical changes in rivers and their floodplains: character, management and restoration’.

The final theme (8), which is integral to all other themes is ‘monitoring, characterising and assessing the condition of river-floodplain ecosystems’. Many of the papers cited under the other themes concern monitoring, characterising and assessing flows, sediments, channel-floodplain forms and biota. However, following particularly from themes 2 and 3, he contributed to research on the monitoring, classification and assessment of ecohydraulic conditions and associated bedforms in river systems, which are particularly relevant here (Emery et al., 2003, 2004; Clifford et al., 2005, 2006).

SPECIAL ISSUE PAPERS

This Special Issue is edited by four close friends and research collaborators of Geoff: his PhD supervisor (Gregory), his colleague from the time when they were both research students at the University of Exeter (Foster), his PhD student (Wood) and an examiner of his PhD thesis (Gurnell). It brings together contributions from many other researchers who worked closely with Geoff on diverse projects at different times during his research career. Together, we have contributed 21 research papers that cover some, but not all, of Geoff’s many interests within the field of river science and in memory of his massive contribution to river research and management. Each of these papers includes at least one author who collaborated closely with Geoff but it is important to stress that these are a very small sample of the many strong collaborations that Geoff formed over his academic career. In this section, we provide a brief overview of these papers and their links to the themes of Geoff’s research presented in the previous section.

The first paper in this special issue was co-authored by Geoff (Neachell and Petts, 2019) and was submitted to the journal shortly before he died. It relates to theme 2, Geoff’s most sustained area of research interest, and focuses on the pioneering work of George Baxter in developing rules for the allocation of environmental flows.

In relation to theme 1 (river channel changes downstream from dams), Ken Gregory (2019) considers the evolution of research on human influences on morphological adjustment of river channels through phases of recognition, realisation and evaluation, whereas Rémi and others (2019) present an adaptive management approach to reduce clogging of river beds downstream of dams, which also provides a cross-over to theme 3.

McGregor (2019) contributes to theme 2 (river flows and flow regimes) by considering the links between climate and rivers, emphasising linkages with flow regimes and hydrological variability and introducing the concept of atmospheric rivers. Dixon and Wilby (2019) further develop atmosphere - river flow linkages by illustrating how seasonal inflows to rivers feeding strategically-important hydropower plants in Kyrgyzstan and Tajikistan can be forecast using information on El Niño conditions. Nestler and others (2019) focus on hydraulic conditions within rivers, providing the

multi-decade history and a review of the Habitat Suitability Criteria Curve as a tool to address water resource issues. Finally, Saltveit and others (2019) document why river ecosystems need floods using experience gained in a regulated Norwegian river.

Foster and others (2019) contribute to theme 3 (river water quality and its management) by examining sediment transfers and connectivity within a lowland agricultural catchment, where they investigate particle size of sediment deposits in small, rapidly silting reservoirs. In contrast, Pinay and Haycock (2019) broaden the focus to encompass riparian zones and review research findings dating back to the 1980s on the role of riparian zones as nitrogen buffers, an important component of the many interactions between land and water that affect river system functioning.

Docherty and others (2019) illustrate theme 4 (alpine and glacial river systems) by considering glacier-fed headwater streams in the Arctic, exploring the impact of climate change on stream hydrological and thermal regimes.

Three papers contribute to theme 5 (riparian vegetation and large wood in river dynamics). Tabacchi and others (2019) explore the biogeomorphological succession driven by interactions between plants and physical processes in river corridors, specifically highlighting the importance of species composition and plant traits. Rodriguez and others (2019) also consider interactions between plants and sediments that give rise to patterns of overbank sedimentation within the lower Orinoco floodplain. Finally, Javernick and Bertoldi (2019) present the results of experimental flume research designed to investigate how gravel-bed braided rivers naturally control vegetation encroachment through morphological processes and the impact of both naturally occurring and induced avulsions on those processes.

On the theme of urban rivers (theme 6), Francis and others (2019) review the literature on non-native species invasions of urban river corridors, including how such invasions relate to the landscape functions of these corridors and the roles they may play in novel urban river ecosystems.

Three papers relate to theme 7 (historical changes in rivers and their floodplains). Stan Gregory and others (2019) illustrate the major hydrological, geomorphological and ecological changes experienced along the Willamette River as a result of human actions over almost two centuries. Gell and others (2019) consider even longer-term changes in the floodplain wetlands of the southern Murray Darling basin but emphasise more recent consequences of human actions and an adaptive management framework which may drive a pathway towards more sustainable management in the future. Finally, Seddon and others (2019) illustrate how investigations of palaeoecological and contemporary macroinvertebrate communities can provide evidence to characterise reference lotic conditions and in doing so provide a direct link between themes 7 and 8.

The final research theme (8 - monitoring, characterising and assessing the condition of river-floodplain ecosystems) is illustrated by four papers. Tydecks and others (2019) present a global survey of freshwater biological field stations, which have played such a fundamental role in monitoring river ecosystems. White and others (2019) explore how the use of new macroinvertebrate biomonitoring tools can be used to examine the short-temporal response of the community to flow intermittence and the transitioning between flowing and channel drying conditions. Keele and others (2019) take a broader view of river ecosystems, presenting a new method for assessing their ecosystem services. Lastly, recent years have seen the rise of citizen science and so Gurnell and others (2019) review the contribution of citizen science volunteers to river monitoring and management and present a new multi-scale tool that citizen scientists are applying to characterise the physical and vegetation habitat structure of rivers.

We all remember Geoff's remarkable scientific contributions but also his extraordinary and mischievous good humour, persistently positive attitude, amazing energy, and generous, reliable friendship. We all miss him enormously but can happily acknowledge that Geoff packed at least twice as much into his far-too-short life as most academics manage. We dedicate this collection of papers to his memory.

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Francis et al

Gell et al

Gregory

Gregory et al

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Keele et al

McGregor

Neachell and Petts

Nestler et al

Pinay and Haycock

Rémi et al

Rodriguez et al

Saltveit et al

Seddon et al

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EXTENDED LIST OF THE PUBLICATIONS OF GEOFFREY E. PETTS PRESENTED IN CHRONOLOGICAL ORDER

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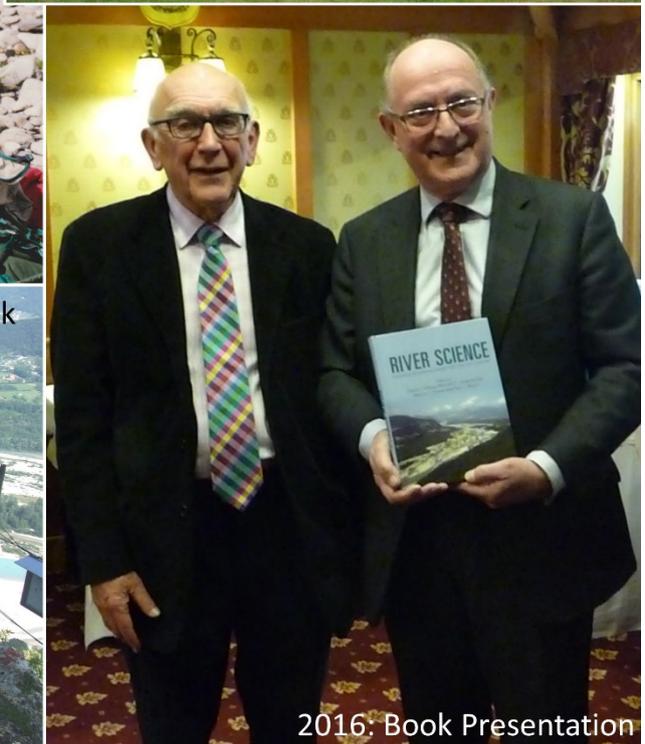
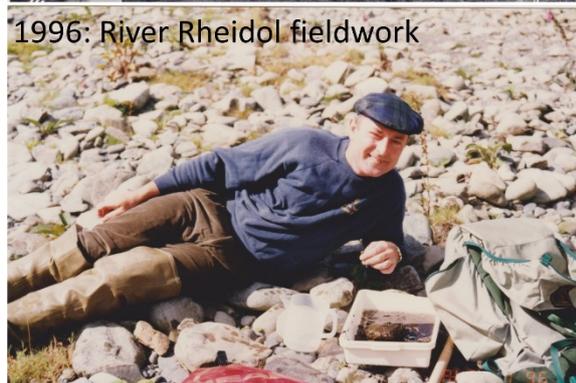
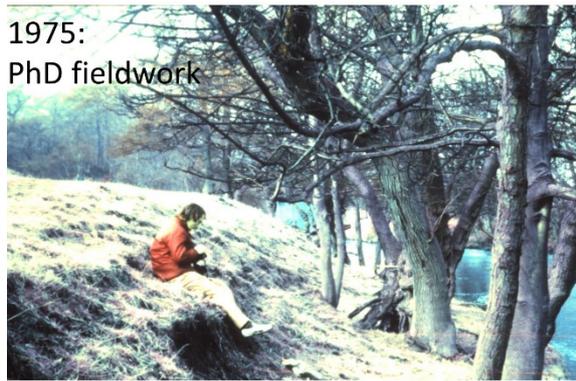


Figure 1: Remembering Geoff Petts – an outstanding, interdisciplinary river scientist

SUGGESTED RUNNING ORDER FOR PAPERS (grouped by themes)

Gurnell, Foster, Gregory, Wood Professor Geoffrey Petts (1953-2108): an outstanding interdisciplinary river scientist (Editorial)

Neachell, Petts. Operationalising the allocation of environmental flows: a UK perspective on Baxter's Schedule

1. River channel changes downstream from dams

Gregory. Human influence on the morphological adjustment of river channels: the evolution of the concepts in river science

Rémi et al. An adaptive management approach to reduce clogging with water releases

2. River flows and flow regimes: natural variability, human manipulation, and flow allocation to protect river ecosystems

McGregor. Climate and Rivers

Dixon & Wilby. A seasonal forecasting procedure for reservoir inflows in Central Asia

Nestler et al. History and Review of the Habitat Suitability Criteria (HSC) Curve in Applied Aquatic Ecology

Saltveit et al. Rivers need floods – lessons learnt from the regulation of the Norwegian salmon river, Suldalslågen

3. Water quality, temperature and sediment dynamics: processes and management

Foster et al. A palaeoenvironmental study of particle size-specific connectivity- new insights and implications from the West Sussex Rother Catchment, UK

Pinay & Haycock Diffuse nitrogen pollution control: moving from riparian zone to headwater catchment approach. A tribute to the influence of Professor Geoff Petts

4. Alpine and glacial river systems – hydrology, geomorphology, ecology and sensitivity to change.

Doherty et al. Arctic river temperature dynamics in a changing climate

5. The role of riparian vegetation and large wood in river dynamics

Tabacchi et al. Species composition and plant traits: Characterization of the biogeomorphological succession within contrasting river corridors

Rodriguez et al. Multi-annual contemporary flood event overbank sedimentation within the vegetated lower Orinoco floodplain, Venezuela

Javernick & Bertoldi. Management of vegetation encroachment by natural and induced channel avulsions: a physical model

6. Urban rivers

Francis et al. An overview of non-native species invasions in urban river corridors

7. Historical changes in rivers and their floodplains: character, management and restoration.

Gregory et al. Historical changes in hydrology, geomorphology, and floodplain vegetation of the Willamette River, Oregon

Gell et al. Management pathways for the floodplain wetlands of the southern Murray Darling Basin: lessons from history

Seddon et al. The use of palaeoecological and contemporary macroinvertebrate community data to characterise riverine reference conditions

8. Monitoring, characterising and assessing the condition of river-floodplain ecosystems.

Tydecks et al. A global survey of freshwater biological field stations

White et al. Invertebrate community and biomonitoring tool variations across sub-seasonal scales in temporary rivers

Keele et al. A new method for assessing river ecosystem services and its application to rivers in Scotland with and without nature conservation designations.

Gurnell et al. The contribution of citizen science volunteers to river monitoring and management: international and national perspectives and the example of the MoRPh survey