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Introduction

CHAPTER 1
Revisiting the Case for River Conservation

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Introduction

Links with the past

In September 1990 the Nature Conservancy Council (NCC) in Great Britain organized an international conference on river conservation and management. It was held at the University of York and attracted 337 delegates from 29 countries around the world. The idea of arranging a similar event at the same venue exactly two decades later was to evaluate the successes and failures over that period and to look ahead over the next 20 years. The way that nature conservation is organized in Britain has changed greatly since 1990. The NCC no longer exists, and it was its successor bodies – Scottish Natural Heritage, Natural England, the Countryside Council for Wales, and the Joint Nature Conservation Committee – together with the environment agencies in the UK, that were responsible for arranging the 2010 conference. Compared with 1990, the 2010 event was held in a considerably tougher economic climate. This was at least partly the reason for the smaller attendance: despite initial expressions of interest from 430 people in 44 countries only 166 from 19 countries finally attended the 2010 conference (Table 1.1).

The main output from York 1990 was a book with the same title as the one in which this chapter appears (Boon *et al*., 1992). It was published at a time when the subject of river conservation and management was at an early stage of evolution. That book has proved valuable over the subsequent years in stimulating further work and debate on these topics. Eleven of the chapters were selected at random, and an analysis made of the numbers of times each has been cited and the geographical region where it has been applied. Of the 240 citations in the ISI Web of Science, two-thirds were related to studies in North America or the British Isles, with most of the rest accounted for by studies elsewhere in western and central Europe and in Australasia (Table 1.2). Various factors are probably responsible but these figures tend to support the view that concepts of river conservation (and nature conservation more generally) applied in developed countries are perceived to be less relevant to developing countries. This aspect was not covered in great detail at the 2010 conference, but relevant discussion can be found in Wishart *et al.* (2000), O'Keeffe and Thirion (2009), Abell and Bryer (2009), Khan and Akbar (this volume) and O'Keeffe (this volume).

This chapter looks back over the last 20 years, describes some of the changes that have taken place in river conservation since the 1990 conference, and considers what still remains to be done. In particular it re-examines the case for conservation

River Conservation and Management. Edited by Philip J. Boon and Paul J. Raven.

Table 1.1 Geographical distribution of delegates attending the rivers conferences in York in 1990 ($n = 337$) and in 2010 ($n = 166$).

Region	York 1990 (%)	York 2010 (%)
British Isles	52	67
Western and Central Europe	16	4
North America	8	8
Southern Europe	7	4
Africa	5	3
Scandinavia	4	2
Australia and New Zealand	4	8
Eastern Europe	2	<1
Asia	1	3
Middle East	1	<1

given in the introductory chapter of the previous book (Boon, 1992). Although it uses examples from around the world, it focuses primarily on mainland Europe and the UK (England, Wales, Scotland and Northern Ireland), and aims to set the broad context for the more detailed chapters that follow in the rest of the book.

Table 1.2 The percentage of published references (from 1993 to 2008) to 11 chapters selected at random from *River Conservation and Management* (Boon *et al*., 1992 – the book derived from the York 1990 rivers conference) according to the region of the world to which the citation applies. Data obtained from ISI Web of Science ($n = 240$).

Region	Proportion of total
North America	39%
British Isles	25%
Australia and New Zealand	12%
Western and Central Europe	11%
Southern Europe	4%
Eastern Europe	2%
Asia	2%
Africa	1%
South America	1%
Middle East	<1%
Scandinavia	<1%

The world then and now

Perhaps it is stating the obvious to say that much has changed in the world since York 1990, yet so profound are the changes in a mere 20 years it is worth summarizing a selection:

Economic changes

- Creation of the 'eurozone' in 17 Member States of the European Union after the euro became legal tender on 1 January 2002.
- The international banking crisis and global recession in 2008–2009.

Geopolitical and social changes

- Human population has increased from 5.3 billion in 1990 to 6.8 billion by 2010.
- The abolition of apartheid with the first democratic elections in South Africa in 1994.
- Several major geopolitical changes, including the collapse of communism in eastern Europe leading to the division of Czechoslovakia into the Czech Republic and Slovakia (1993); the creation of independent Balkan states such as Serbia and Croatia in place of Yugoslavia (beginning in 1992); the formation of a united Germany following the dismantling of the Berlin Wall in December 1989; the expansion of the European Economic Community comprising 12 countries into the European Union of 27 Member States.
- Devolved legislative powers from the UK Government in Westminster to administrations in Scotland, Wales and Northern Ireland.
- A formal end to military activities by the Irish Republican Army (IRA) in Northern Ireland.
- Two wars in Iraq and a war in Afghanistan.
- Destruction of the Twin Towers in New York on 11 September 2001.

Technical advances

- Computing power increasing by several orders of magnitude.
- A digital revolution, leading to the invention of laptop computers, mobile phones, global positioning systems (GPS), satellite TV.
- Launch of the World Wide Web (August 1991).
- Remote sensing (e.g. improved aerial photography, satellite imagery, LiDAR (Light Detection and Ranging)).

Changes in language and communication

- A decline in formal written communications in favour of informal e-mails and text messages.
- Development of social networking websites such as Bebo (www.bebo.com) Myspace (www.myspace.com), Facebook (www.facebook.com) and Twitter (http://twitter.com).
- Continuing deterioration in the standard of written English, especially among native English-speakers.
- Infiltration of business jargon into every area, including ecology and conservation.

River conservation does not take place in isolation from its economic, geopolitical, social, cultural and technological context. Conservation costs money; it is influenced by government policies; it reflects social and cultural values; it takes advantage of developments in science and technology. How has the case for river conservation changed over the past 20 years? What are the priorities for the next 20?

The case for river conservation

Use and abuse

Rivers are rarely lost to the landscape altogether – unlike other natural features such as native woodlands, ponds or hedgerows. Generally speaking, the rivers in 1990 still flow in 2010 yet may be profoundly changed in their channel shape, flow rate, water quality, habitat structure, or connection with their surrounding corridors. Rivers are perhaps the most intensively used ecosystems on the planet, with a huge increase in the amount of water extracted globally (especially for agriculture) over the past century (Plate 1), and subject to a litany of impacts at a range of scales from 'supra-catchment' to instream (Table 1.3). Considerable progress in reducing some types of river pollution has been made across Europe since 1990. For example, emissions of sulphur dioxide have declined significantly, leading to a smaller area subject to, and at risk of, acidification (European Environment Agency, 2010). The concentration of phosphate in rivers has also fallen, largely through implementing the EC Urban Wastewater Treatment Directive (Council of the European Communities, 1991; European Environment Agency, 2010), although nutrient enrichment from diffuse sources remains a cause for concern. In England and Wales the number of serious pollution incidents has steadily declined (Figure 1.1). Yet, despite these improvements, recent assessment and monitoring under the EC Water Framework Directive (Council

Table 1.3 The principal categories of human activities affecting river systems at a range of spatial scales (amended from Boon, 1992).

Supra-catchment effects
Acid deposition
Inter-basin transfers
Climate change
Catchment land-use change
Afforestation and deforestation
Urbanization
Agricultural development
Land drainage/ flood protection
Corridor engineering
Removal of riparian vegetation
Flow regulation – dams, channelization, weirs, etc.
Dredging and mining
Instream impacts
Organic and inorganic pollution
Thermal pollution
Abstraction
Navigation
Exploitation of native species
Introduction of alien species

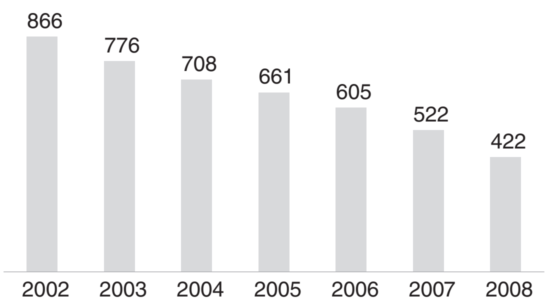

Figure 1.1 Serious pollution incidents affecting water in England and Wales, 2002 to 2008 (Source – http://data.gov.uk/dataset/serious-pollution-incidents-affecting-water-air-and-land-2002-to-2008).

of the European Communities, 2000) shows that all is not well. For example, as a result of pressures such as diffuse pollution, abstraction and river engineering, 46% of rivers in Scotland (http://www.sepa.org.uk/water/monitoring_and_classification.aspx), 74% in England and Wales (http://www.euwfd.com/02-SH091002_EA_WFD_Update.pdf), and 75% in Northern Ireland (http://www.doeni.gov.uk/niea/water-facts-booklet-2011.pdf) are currently at risk of failing to meet the Directive's target of reaching 'good ecological status' or better by December 2015. At a global scale, Vörösmarty *et al*. (2010) concluded that 65% of river discharge and the aquatic habitat it supports are under moderate to high threat, but that far less investment has been directed at biodiversity conservation than to human water security. In general, the pressures affecting rivers in 1990 (Boon, 1992) are very similar to those affecting rivers today (Table 1.3). Nevertheless, there are some differences in emphasis and one notable addition.

In 1990, there were 14 280 large dams registered worldwide (International Institute for Environment and Development and World Resources Institute, 1987; Boon 1992). The Worldwide Fund for Nature (WWF) reports that the number has now increased to 48 000, about half of which are in China, with a storage capacity of about 6000 km^3 (http://wwf.panda.org/what_we_do/footprint/water/dams_initiative/quick_facts/.). Dam construction is no longer centred principally in North America or in Europe but in countries such as Iran and parts of Asia. With the growing demand for water, both the numbers of dams and their density on river networks have increased substantially over the past 20 years. So has their size, advances in engineering technology having made possible dam projects on a previously unimaginable scale, such as the Three Gorges Dam in China (Plate 2).

Two specific human impacts on river systems deserve particular mention:

Invasive alien species

The introduction of invasive alien species is not a new phenomenon. Since 1990, however, there have been substantial increases both in the number of alien species recorded and the extent of their invasions, as well as a greater awareness of the damage that they cause. In the UK, some of the most serious threats to rivers from invasive alien species are from North American signal crayfish (*Pacifastacus leniusculus*) (Crawford *et al*., 2006) and from bankside species such as Japanese knotweed (*Fallopia japonica*) and *Rhododendron ponticum* (Hladyz *et al*., 2011). The management response to these threats has been encouraging, and marks a positive step in the right direction over the past 20 years. In the UK, for example, there are practical measures in place at a local and regional scale to deal with invasive species, as well as strategic planning at a national level. A recent invasion shows that the importance of reacting quickly is now recognized by government bodies and others. In September 2010 *Dikerogammarus villosus* ('killer shrimp') (Plate 3) was recorded for the first time in the UK at a public water supply reservoir in eastern England (Grafham Water, Cambridgeshire) (http://www.environment-agency.gov.uk/news/123209.aspx?page=8&month=9&year=2010). The shrimp is native to the Ponto-Caspian region and spread across Europe following the opening of the Danube-Main-Rhine canal in 1992. It is known to be a voracious predator on other invertebrates and young fish and is a serious threat to ecological integrity. The Environment Agency responded immediately, and with the water supply company, fishing organizations, boating clubs and others quickly worked together to put in place practical 'biosecurity' measures to prevent further spread of the organism.

In Great Britain a strategy for tackling non-native invasive species has been published (Defra, 2008) and a management structure set up to put it into practice (https://secure.fera.defra.gov.uk/nonnativespecies/home/index.cfm). Part of the process involves carrying out detailed risk assessments of alien invasive species. This is undertaken by species experts and is based on scientific evidence, so that the results can be used to decide what action (e.g. eradication, control, mitigation) to take in each situation. Many of the risk assessments completed so far are for aquatic species, some of which, such as signal crayfish and Japanese knotweed, occur in or near rivers.

An awareness of the serious threat that invasive alien species pose to biodiversity and to ecosystem services now extends across Europe and beyond. For example, the European Commission is developing an invasive non-native species strategy (http://ec.europa.eu/environment/nature/invasivealien/index_en.htm) as part of its goal of halting the decline of biodiversity by 2020. This initiative is supported by a range of European and global databases (e.g. DAISIE – http://www.europe-aliens.org/index.jsp) which have been compiled to show the distribution of alien species, provide information on their biology, and suggest methods of prevention and control.

Global climate change

Potential threats from climate change were certainly being discussed in 1990, but interest and concern — by scientists, politicians and the general public — has grown substantially since then. By coincidence, the issue of *New Scientist* that was published the week before the 1990 conference contained a leading article on the subject, where the tenor of the text was strikingly similar to articles written 20 years later: 'It was a sight to behold. There were the Americans, in Sweden last week for the Intergovernmental Panel on Climate Change, repeating their government's well-worn homilies about global warming: how uncertain all this science is, how expensive it would be to do anything, how silly to get excited until we are absolutely sure the world is in peril.' (*New Scientist* no. 1733, 8 September 1990).

Yet the impact of climate change on river conservation and management was rarely mentioned 20 years ago. In *River Conservation and Management*, derived from the 1990 conference (Boon *et al*., 1992) there is just one passing reference to climate change. In his chapter on river conservation and catchment management, Newson (1992) said: 'There remains a deficit of knowledge in relation to the predictive ability to manage long-term; sustainability requires predictability, and climate change is making predictability particularly difficult for river systems'.

The lack of scientific data on rivers and climate change 20 years ago is well illustrated in a recent editorial in *Aquatic Conservation* (Ormerod, 2009) where 43 of the 44 references cited were published in the year 2000 or later. However, sufficient evidence on the effects of climate change on river temperature (Langan *et al*., 2001; Webb and Nobilis, 2007), and on flow regimes (Barnett *et al*., 2006) has now been accumulated to show that in many parts of the world rivers will be profoundly affected during this century. Ecological impacts (compounded by increasing human demand) are likely to be many and varied, including direct effects on life cycles and growth rates from rising temperatures or displacement of animals and plants through higher flows; and indirect effects such as the flow-related dilution of pollutants or transport of sediments (Ormerod, 2009, Cosgrove *et al*., this volume, Ormerod and Durance, this volume). The influence of climate change on rivers will undoubtedly be near the top of the list of threats over the next few decades (Strayer and Dudgeon, 2010).

The place of nature conservation within a wider framework

Nature conservation (including the conservation of river habitats and species) is increasingly considered as part of a much wider framework of environmental policy and practice. The last two decades have experienced significant changes around the world in environmental regulation, and in the organizational structures and legislation needed to carry it out.

In 1990, the York rivers conference was arranged by the Nature Conservancy Council (NCC) – the statutory body responsible for Nature Conservation in England, Wales and Scotland. In 1991 the British government abolished the NCC and replaced it with separate, statutory 'country agencies' – English Nature (now Natural England), the Countryside Council for Wales, and Scottish Natural Heritage – and set up the Joint Nature Conservation Committee to provide an overview for Great Britain as a whole. The roles and responsibilities have changed to some extent over the years; all three now have broader remits than the NCC – advising government, offering advice to the public and developers, giving grants, and funding research not just on conservation but also on landscape matters and on informal recreation in the countryside.

At the same time, the way that rivers are managed and regulated in the UK has also changed substantially. In 1989 the National Rivers Authority (NRA) was established with responsibility for water resource management, monitoring and regulating pollution, and for flood control and land drainage. Rather different arrangements applied in Scotland, with 10 River Purification Authorities (RPAs) undertaking pollution control and water quality, but with other bodies responsible for water supply, flood prevention and land drainage. Although the NRA had a statutory duty with respect to the conservation of flora and fauna, the RPAs did not, sometimes leading to tension between the conservation bodies and the water regulators.

The arrangements for river management changed in April 1996 with the creation of the Environment Agency in England and Wales to replace the NRA, and the Scottish Environment Protection Agency replacing the RPAs in Scotland. Both bodies have important biodiversity and conservation duties, and much stronger links have been forged with the statutory conservation agencies.

Non-governmental organizations (NGOs) in the UK were already active in river conservation and management at the time of the 1990 conference, but their influence and involvement has grown steadily since then. Notable among these are the River Trusts in England and Wales (Newson, this volume), the Rivers and Fisheries Trusts in Scotland, and bodies such as the Royal Society for Protection of Birds (RSPB) and the Worldwide Fund for Nature (WWF) which published the results of a three-year project in the 1990s on river restoration (*Wild Rivers*: WWF, 1998). In many other countries, too, the NGOs and the wider public have become progressively more involved in addressing freshwater resource issues (Showers, 2000). In the US, for example, there are several large and influential NGOs, such as the Nature Conservancy, Sierra Club and American Rivers, actively engaged in these areas (Karr *et al*., 2000; Pringle and Withrington, 2009).

Since 1990, river conservation in Britain, and in the rest of the European Union, has also benefited from the passage of two important directives – the EC Habitats Directive (Council of the European Communities, 1992) and the EC Water Framework Directive (Council of the European Communities, 2000) (Boon and Lee, 2005). The stated aim of the Habitats Directive (HD) is 'to contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the Treaty applies'. Annex I lists 'natural habitat types of Community interest whose conservation requires the designation of Special Areas of Conservation' (SACs); Annex II does the same for individual animal and plant species. Only one of the nine river types in Annex I occurs in the UK: 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation'. Species on Annex II associated with rivers comprise two invertebrates (freshwater pearl mussel (*Margaritifera margaritifera*) and white-clawed crayfish (*Austropotamobius pallipes*)) and eight fish, including river lamprey (*Lampetra fluviatilis*) and Atlantic salmon (*Salmo salar*).

It is clear, therefore, that the diversity of rivers and associated species in the UK (and elsewhere in Europe) cannot be adequately represented in the list of protected areas selected under the HD (Boon and Lee, 2005). Yet, since the passage of the Directive, a great deal of effort in the UK has been put into selecting and designating river SACs (both for river habitat and for species), devising monitoring programmes, and reporting to the UK government and to the European Commission on the condition of the designated features in each site. While the statutory conservation agencies have stated their intention to take a broader, 'wider countryside' approach to nature conservation, limited resources inevitably means a concentration of effort on protected sites, even though they comprise a very small fraction of the land and water in the country as a whole.

The EC Water Framework Directive (WFD) is not a nature conservation directive *per se*, and the

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concept of 'ecological status' enshrined within the Directive is not synonymous with 'conservation value', yet the WFD has much to offer nature conservation (Boon and Lee, 2005). Article 1 of the WFD summarizes the main aims of the Directive:

- to prevent further deterioration of aquatic ecosystems and to protect and enhance their status (including wetlands directly depending on aquatic ecosystems);
- to promote sustainable water use;
- to reduce pollution to groundwater and to surface water;
- to contribute to mitigating the effects of floods and droughts.

A 'departure from naturalness', which lies at the heart of the Directive and assessed in terms of ecological status, is an important component (perhaps the most important component) of conservation value but it is not the only one (Ratcliffe, 1977; Boon *et al*., 1997, 2002; Boon, 2000; Dunn, 2004).

Consequently, while the HD and the WFD both have a valuable role to play in furthering river conservation in Europe, this role is limited. Assessing the conservation value of rivers only to meet the requirements of European legislation will produce an unbalanced picture. The last 20 years have seen many new approaches to evaluating fresh waters in general, and rivers in particular (Boon and Pringle, 2009). Some methods have been designed to help select a representative set of rivers for protection (Chadderton *et al*., 2004; Leathwick *et al*., this volume) while others have broader objectives (Kleynhans, 1996; Boon *et al*., 1997). One overriding aim, in all cases, has been to move from decisions based largely on subjective judgements to those supported by scientific evidence.

Scale and connectivity

Understanding of the significance of scale in the way rivers function, and therefore in their conservation and management, has grown impressively over the last 20 years. Just before the 1990 conference, a paper by Ward (1989) on the 'four-dimensional nature of lotic ecosystems' drew attention to the importance of 'connectivity' – between upstream and downstream reaches; between river channels, riparian zones and floodplains; and between the surface of the river bed and sub-surface regions.

In the early to mid 20th century, research on running waters looked inward to the ecological factors that affect the distribution of organisms (Percival and Whitehead, 1929; Macan, 1963). Much of the credit for looking outward, for broadening the appreciation of rivers as integral parts of the landscape, should be given to Noel Hynes' brief but influential paper on 'the stream and its valley' (Hynes, 1975). His succinct description of the way 'the valley rules the stream' – with river communities shaped by their underlying geology, soils, precipitation, and organic inputs – has been expanded by many others over the past 35 years to provide the scientific basis for integrated catchment management (ICM). It is only comparatively recently, however, that ICM has become the basis of a statutory requirement throughout the European Union following the adoption of the WFD. Yet the WFD takes a rather patchy approach to scale and to connectivity. On the one hand, there is a requirement to produce river basin management plans, to monitor the status of water bodies, and to put in place 'programmes of measures' to ensure that the environmental objectives of the Directive are met. On the other, the assessment of ecological status does not recognize explicitly the three types of connectivity described above. The importance of longitudinal connectivity is recognized but only in forming part of the assessment of rivers at the highest level of ecological status. To be classified as such, 'The continuity of the river [should not be] disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.' The same level of assessment also applies to lateral connectivity between a river and its riparian zone. Floodplain habitats are not included explicitly although wetlands dependent on aquatic ecosystems are covered to some extent by the WFD.

Research on the hyporheic zones of rivers (the vertical dimension) has increased rapidly over the last 20 years; papers have now been published on this topic in many countries, of which the following are merely examples: North America (Wright *et al*., 2005), Australia (Boulton *et al*., 2007), France (Nogaro *et al*., 2010), Austria (Danielopol and Pospisil 2001), and the UK (Wood *et al*., this volume). Despite growing interest in the vertical connectivity within rivers and the significance of hyporheic zones in river functioning, they form no part in ecological status assessment under the WFD (Wood *et al*., this volume).

Thus, while significant progress has been made since 1990 in understanding the importance of scale and connectivity in river processes, translating science into policy and practice still has some way to go.

Strengthening the case – 20 years further on

At the York conference in 1990, Boon (1992) suggested 10 ways in which the case for river conservation could be made more effectively: the application of theoretical ecology to river conservation; increased research effort; studies on habitat requirements of river biota; taxonomic work; scientific publication; national and international co-ordination; improved procedures for Environmental Assessment; adaptive management in river modification schemes; long-term monitoring; and public education and participation. Looking ahead to the next 20 years, where do we go from here? What are some of the issues needing attention in furthering the cause of river conservation in the first half of the 21st century?

The need for basic research

The decline in freshwater research in the UK has been accompanied by a change in direction of research priorities as universities and research institutes seek external funding to boost shrinking budgets (Battarbee *et al*., 2005; Raven 2006). In particular, the last 10 years have seen significant sums of money spent on developing new methods for assessing ecological status under the WFD. Although EC directives are important, effective river conservation and management needs much more than this. A solid foundation of river science is an essential prerequisite and any reduction in basic research in this area will ultimately impoverish the 'evidence base' that government bodies and others claim is so important in environmental management. Even simply trying to implement the requirements of the WFD has encountered problems through an insufficient understanding of ecological processes. For example, environmental regulators need to know how activities such as river engineering are likely to affect aquatic organisms, but understanding the relationship between physical habitat and biological communities still has a long way to go (Vaughan *et al*., 2009).

There is more to conservation than ecosystem services

The concept of 'ecosystem goods and services' is not new, neither is the term itself which was coined in the 1960s, yet in 1990 the services provided by rivers to human society ('supporting', 'provisioning', 'regulating' and 'cultural' – Plate 4) were rarely discussed in quite that way. The Convention on Biological Diversity (United Nations, 1992) rightly emphasized the inextricable links between human societies and the ecosystems of which they are part and on which they depend (Bridgewater *et al*., this volume; Everard, this volume). Now, since publication of the *Millennium Ecosystem Assessment* (2005) the justification for nature conservation often seems to be based mainly on ecosystem services. Sadly, the philosophical principle that habitats and species have a right to exist, irrespective of the value they represent for human beings, no longer seems to command much respect. A more 'traditional' approach to conservation lies at the heart of the EC Habitats Directive, and discussions continue on whether a focus on ecosystem services can meet the needs of nature conservation (Palmer *et al*., 2004; McCauley, 2006; Reid, 2006). There will, of course, be real differences in approach to nature conservation in general, and river conservation in particular, between developed countries and those in developing parts of the world where addressing the problems of water scarcity and the alleviation of poverty are critically important.

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Here, an ecosystems approach to conservation is more likely to bring real benefits for biodiversity and for human communities than attempting to impose more traditional 'western' views of nature conservation (Abell and Bryer, 2009; Mathooko *et al*., 2009; O'Keeffe and Thirion, 2009).

Rivers as protected 'sites'

Nature conservation has always relied on the idea that parcels of land can be protected from human development and activity by some form of legal designation, and the practice of selecting nature reserves or other 'sites' for protection occurs universally. In the European Union an extensive network of Special Areas of Conservation ('*Natura 2000*') has been established to safeguard particular types of habitats and threatened species. Some of these SACs are rivers, with examples from the UK including the Avon in England (Plate 5a), the Tweed in Scotland (Plate 5b), the Tywi in Wales (Plate 5c) and the Upper Ballinderry in Northern Ireland (Plate 5d). Taken together, however, the 'qualifying interests' for these four high-quality rivers cover only a very small proportion of their plant and animal communities – the river habitat in Annex I (described earlier), otter (*Lutra lutra*), Atlantic salmon, sea lamprey (*Petromyzon marinus*), river lamprey, brook lamprey (*Lampetra planeri*), bullhead (*Cottus gobio*), freshwater pearl mussel, Desmoulin's whorl snail (*Vertigo moulinsiana*) and floating water-plantain (*Luronium natans*). In addition, the difficulty of trying to squeeze rivers into the traditional mould of terrestrial site protection has long been recognized, because legal designations rarely extend to entire catchments and often stop at the top of the river bank. Consequently, more is expected of legislation that supports river basin management (e.g. the WFD) as a way of securing some of the aims of nature conservation. The role of protected areas in future strategies for river conservation is a topic ripe for debate and action.

Restoration or conservation?

In the broadest sense, river restoration can be considered a form of river conservation. At the rivers conference in 1990, Boon (1992) set out five management options for rivers along a spectrum of decreasing conservation value. At the high-quality end of the spectrum there is a case for *preservation* of those few remaining examples of natural or near-natural river systems. Where river 'quality' remains high but where human pressures are evident, the preferred option changes from preservation to *limitation* of catchment development; further along the spectrum the need is for *mitigation* of damage, then for *restoration* of degraded stretches, and finally, at the end of the spectrum, for *dereliction* – giving up and accepting the status quo when improvement is impossible or when the costs outweigh the benefits. The science of river restoration has made significant progress since 1990 (Kondolf, this volume). Yet there are still difficult policy decisions to be made. For example, should time and money be spent on restoring the worst rivers to a level of mediocrity or to ensure that the rivers of the highest quality are kept in that condition? Can the restoration of rivers in Europe to 'high ecological status' be justified when the WFD only requires the target of 'good ecological status' to be met? Where rivers are already at high ecological status how can they be maintained at that level when resources are limited?

River restoration is one area where an ecosystem services approach can pay dividends for nature conservation. However, this requires a careful analysis of the costs of restoration and the benefits both for biodiversity and for human communities, and needs an understanding of the relationship between ecosystem services and the hydrogeomorphic character of the river section under consideration (Thorp *et al*., 2010).

River management versus river conservation

Boon (2000) suggested that there are clear distinctions between what is usually considered the role of river 'managers' and those interested in river 'conservation'. Nature conservation highlights the intrinsic value of the special or extra-ordinary (the natural, the rare, the threatened, the diverse) yet still appreciates the ordinary. It lays stress on 'non-use' (e.g. aesthetic) values while realizing the importance of 'use' (e.g. economic) values. River management focuses on the ordinary but still recognizes the value of the uncommon. It emphasizes uses, but does not neglect non-use values. With the passage of time, these two domains have grown closer together, encouraged (in Europe) by legislation such as the WFD. Indeed, since 1990, public bodies in the UK have been given a statutory biodiversity duty to be exercised when carrying out their work, but the environment agencies and the conservation agencies still have distinct roles to play. There will not always be total agreement, but the challenge is to find common ground and the right balance when deciding which activities should be permitted and which are likely to jeopardize conservation values. At present, for instance, the UK environment and conservation agencies are debating whether the environmental standards used under the WFD (e.g. for nutrients or for river flow) are sufficiently stringent to protect river SACs.

In all of this there is an overriding need for a genuinely holistic view of rivers and their catchments, and assessments of conservation value at a national (or even an international) scale. Boon (1992) said 'The time has come, then, to press for conservation strategies which encompass the river resource as a whole, so that the proponents of conservation are not continually forced to fight battles for individual [river] systems. This means better management now, sensitive planning in the future, and undoing at least some of the damage of the past'.

The time has surely come to put words into action.

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