1 · *Introduction*

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Challenges facing freshwater ecosystems are immense. Moreover, we have entered an unprecedented era of globalization, climate change and increased urban development where these factors are interacting (often in ways that we do not yet completely understand) to undermine the integrity of freshwater ecosystems. The global human population may reach 10 billion by 2050, with increasing demands for freshwater resources and consequent negative effects on lakes and streams.

On an encouraging note, freshwater resource and conservation issues are finding their way more and more into the public consciousness, with a rapid increase in available information on freshwater conservation relative to general nature conservation (Table 1.1). International political recognition of the global water crisis is evidenced by the formation of the World Water Council in 1996. Its mission is 'to promote awareness, build political commitment and trigger action on critical water issues at all levels and to facilitate the efficient conservation, protection, development, planning, management and use of water in all its dimensions on an environmentally sustainable basis for the benefit of all life on earth' (www.worldwatercouncil.org). The World Water Forum (which is a product of the World Water Council) is held every 3 years and provides a much-needed platform for international communication, with the goal of reaching a common strategic vision on water resources and water services management.

Despite this increasing public and international awareness of freshwater resource and conservation issues, conservation studies of freshwater ecosystems are often neglected or overlooked within the field of conservation science. For example, in a recent paper, Lawler *et al.* (2006) attempted to assess gaps in conservation research over a 20-year period. In this 20-year 'report card', based on 628 papers from 14 journals, it was concluded that only 21% of all conservation research covers aquatic ecosystems. This conclusion is misleading as the survey did not include many of the aquatic journals in which conservation-related papers are published, such as *Aquatic*

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Table 1.1 *Number of websites containing conservation-related terms, found using the search engine 'Google.co.uk' in December 2007 compared with May 2005*

Search term	2005	2007	change (%)
Nature conservation	950 000	1 490 000	+57
Natural resource conservation	414 000	348 000	−16
Habitat conservation	373 000	527 000	+41
Species conservation	179 000	244 000	+36
River conservation	89 900	125 000	+39
Wetland conservation	89 500	116 000	+30
Aquatic conservation	35 700	48 200	+35
Lake conservation	23 300	48 200	+107
Freshwater conservation	955	14 000	+1366

Conservation, *Freshwater Biology*, *River Research and Applications*, *Journal of the North American Benthological Society*, *Limnology and Oceanography*, *Canadian Journal of Fisheries and Aquatic Sciences*, *Transactions of the American Fisheries Society*, *Fisheries* and *Journal of the American Water Resources Association*. Similarly, rivers have been largely omitted from the mainstream scientific literature that deals with the management and conservation of fragmented landscapes (but see Pringle, 2006; Crooks & Sanjayan, 2006). Thus, it is critical to communicate more effectively the importance of freshwater ecosystems and methods for assessing the value of fresh waters for conservation.

Towards that end, this book is about the process of assessing the value of fresh waters for nature conservation, and is an outgrowth of two other books on freshwater conservation by one of the editors (Boon *et al.*, 1992, 2000). There are many definitions of the term 'conservation', but in the context of this volume we understand it to mean the maintenance of natural resources through protection, careful management and, where necessary, rehabilitation or restoration. There will always be a degree of subjectivity in what is considered 'important' or 'valuable' in the area of freshwater conservation. However, unless there are some generally accepted protocols for assessing conservation value, it is difficult to make progress in selecting rivers or lakes for special protection, or in determining the relative merits of catchment development in one place as opposed to another. Incentives for freshwater conservation range from the practical to the philosophical. Freshwater ecosystems provide critical goods and services to human societies, including water purification, flood control and nutrient cycling (National Research Council, 2005). Nature can also be assigned value for

its own sake – a recognition both of the 'rights' of habitats and species to exist and of their role in enriching human experience. This may be predominantly a 'first-world' view (see Chapter 12; Boon *et al.*, 2000; Wishart *et al.*, 2000), but extremely relevant where it is invoked.

This book takes an innovative approach to the assessment of fresh waters for their nature conservation value by examining the subject from both sides of the Atlantic. The UK and the USA, although very different in size, landscape, climatic variation, history and politics, have each had a long association with freshwater science. In contrast, nature conservation policy and practice are quite different in both countries. In the UK (i.e. England, Scotland, Wales, Northern Ireland), the conservation movement has developed through mainstream government agencies over more than half a century, influenced strongly by European legislation. The USA, while strongly influenced by national legislation, is clearly less influenced by international legislation, and non-governmental organizations (NGOs) have played a key role in the development of freshwater conservation for natural values (Chapter 3).

Most of the chapters in this book have been written by pairs of authors – each pair comprising one author from the UK and one from the USA. Compiling this volume has been an interesting and challenging experience, not least because authors and editors alike have discovered the limitations in their knowledge and understanding of how things work in each other's countries. The contributors to this book are drawn from a wide range of organizations – government conservation agencies, NGOs, universities, research institutes, consultancies – but all share in common a direct involvement in freshwater science and the conservation of freshwater habitats and species. In writing each chapter, the authors have followed some general principles set out by the editors. First and foremost, the book is about the assessment of 'natural values' of freshwater ecosystems – specifically habitats, biota and ecological processes – rather than wider aspects such as economic or aesthetic values. It covers the evaluation of rivers and lakes, rather than attempting to extend its scope to other freshwater systems such as ponds or wetlands. This is not due to a lack of recognition of their importance, but rather as a practical means of limiting the length of the book. To some extent it also reflects the present balance of freshwater work in the UK and the USA, especially in response to recent legislative imperatives such as the EC Water Framework Directive (in the case of the UK).

A brief 'road map' for this edited volume is as follows: In Chapter 2 (Boon & Pringle), we set the philosophical context for the book and

provide background information. Chapter 3 (Pringle & Withrington) sets out examples of freshwater conservation in action, contrasting approaches in the USA and the UK. Chapter 4 (Higgins & Duigan) discusses ways of evaluating the 'best' rivers and lakes for conservation, while Chapter 5 (Frissell & Bean) focuses on the importance of conservation evaluation when responding to catchment development. Chapter 6 (Langford & Frissell) goes a step further and looks at evaluating the potential for freshwater restoration, while Chapter 7 (Boon & Freeman) and Chapter 8 (Duker and Palmer) describe some of the techniques used in the conservation evaluation of rivers and lakes, respectively. Although the primary aim of the book is to compare approaches to freshwater evaluation in the UK and the USA, we have attempted to provide a flavour of what is happening in other places too. Towards that end, overviews of freshwater evaluation and conservation in Sweden (Chapter 9; Willen), Australia (Chapter 10; Nevill & Boulton) and South Africa (Chapter 11; O'Keeffe & Thirion) have been included in three short supplementary chapters, as examples of other developed countries where important contributions have been made to designing freshwater conservation assessment techniques. Chapter 12 (Abell & Bryer) examines this subject from a developing country perspective, where economic and social conditions impose a rather different conservation ethic from that of the developed world. Finally, the book ends with concluding remarks (Chapter 13; Pringle & Boon).

The field of freshwater conservation is not static. It constantly changes to meet the demands of new legislation, new environmental pressures, new understanding in science and the constantly shifting patterns in biological populations and communities. We hope that this book will contribute to the practice of conservation as it continues to develop in the UK, the USA and throughout the world.

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2 · *Background, philosophy and context*

PHILIP J. BOON AND CATHERINE M. PRINGLE

Introduction

Conservation for natural values, as an acceptable goal of freshwater resource management, is a relatively recent phenomenon in the USA and the UK, reflecting changes in societal needs and perceptions. These two countries are not alone in this, representing a much wider environmental awareness in the developed, and parts of the developing, world.

In the USA, the development of ideas regarding conservation in general, which influenced the emergence of freshwater conservation as a competing use, can be linked to three general philosophical conservation movements (Calicott, 1990): (1) the Romantic-Transcendental Conservation Ethic of the mid-1800s which stressed that nature has uses other than human economic gain (this was a basis for initial activism by many private conservation organizations whose goals were to save natural areas in pristine state for their inherent value); (2) the Resource Conservation Ethic at the turn of the twentieth century which is based on a utilitarian philosophy (whereby nature is equivalent to natural resources) leading to the 'multiple use concept' which is the current mandate of several US public land management agencies (e.g. US Forest Service and Bureau of Land Management); and (3) the Evolutionary-Ecological Land Ethic of the twentieth century based on the development of the science of ecology and evolution, where nature is viewed as a complicated and integrated system of interdependent processes and components. In the USA, NGOs have been quick to adopt this ethic – with federal and state agencies also including it in their new mandates.

While the Evolutionary-Ecological Land Ethic is the most biologically comprehensive approach to conservation, it is still only part of decision making since economic and social needs of people must also be met. However, it is clear that the science of ecology and evolution (as evinced by the Evolutionary-Ecological Land Ethic) is playing an increasingly greater role in the conservation of freshwater systems in both the USA and the UK.

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Although the formal practice of nature conservation in the UK is little more than 50 years old (the term 'nature conservation' came to prominence only in the 1940s (Sheail, 1998)), its roots can be traced back for several millennia. The expansion of primitive agriculture in the Neolithic era (4500–2000 BC), the development of permanent settlements and the clearance of native woodland represent some of the key stages in the evolution of the British countryside closely linked with changing attitudes to the care and stewardship of the land.

By the late seventeenth century, 50% of England and Wales was committed to agriculture. Yet as people became isolated from the countryside in urban areas in the seventeenth and eighteenth centuries, negative attitudes regarding the value of natural wilderness began to change and a new awareness of wildlife and an enjoyment of natural scenery for its own sake began to grow (Allen, 1976; NCC, 1984; Evans, 1992). The eighteenth century may be considered the turning point towards modern conservation, with a move away from landscape architecture to an appreciation of more natural landforms (Nicholson, 1987). Two additional factors contributed to the development of the conservation movement in Britain. The first was the study of natural history that began in the seventeenth century as a middle-class social pastime (Nicholson, 1970; Evans, 1992) and flourished in the eighteenth, nineteenth and early twentieth centuries. The second was the formation of conservation member societies in the late nineteenth and early twentieth centuries, such as the Society for Protection of Birds (1891). Similar moves were afoot in the USA, with the creation of bodies such as the National Audubon Society (1902) and the National Wildlife Federation (1930) (Nicholson, 1987).

It is difficult to disentangle the development, specifically, of freshwater conservation from this more general evolution of nature conservation in Britain. Perhaps the greatest influence was the growth of freshwater science in the early twentieth century as a discipline in its own right, and in particular the founding of the Freshwater Biological Association in 1929.

In the USA, rivers have been central to the overall conservation movement (Palmer, 1994). For example, in 1910 the Hetch Hetchy Valley dam controversy on California's Tuolumne River was an important event in sparking public awareness of the importance of conservation. Although the battle to stop the dam was lost and this spectacular valley was flooded, the event gave rise to the National Park Service and the establishment of parks to protect wilderness and scenic areas. Only a few dams were stopped during the first half of the century – all in national parks. Aggressive opposition to dams did not occur until the 1960s and 1970s – with the

founding event of the Echo Park Dam battle on the Green and Yampa Rivers in Colorado, which provided the impetus for the Wilderness Act in 1964 (Palmer, 1994). It is also instructive to note that one of the leading modern-day conservation NGOs in the USA, the Sierra Club, evolved out of the fight to protect the Grand Canyon from dam operations.

In Britain, much of the freshwater research undertaken in the first half of the twentieth century was strictly pure science; any attempts at applying scientific knowledge to freshwater conservation and management were largely restricted to tackling the legacy of the industrial and agricultural revolutions, especially the impacts of point-source pollution (Macan, 1951). There are parallels in the USA, where national attention was focused on cleaning up the most severe point-source pollution problems with the passing of the Clean Water Act of 1972. In Britain, by the time the NCC produced its first annual report in the mid-1970s, it was recognized that the problems confronting freshwater conservation were far wider than point-source pollution, including water abstraction, diffuse pollution, land drainage activities, river engineering, reservoir construction and water transfer schemes (NCC, 1975).

Likewise, the USA shifted from a focus on point-source pollution in the 1970s and 1980s to addressing also the regulation of diffuse pollutant inputs, maintaining critical instream flows and regulating river diversions and groundwater extraction – activities that have characterized the 1990s up to the present.

The importance of applying freshwater science to conservation will be discussed later in this chapter, and further comparisons of how conservation practices are implemented in the USA and the UK will be reviewed in Chapter 3.

The aim of this chapter is to set the context for the remainder of the book: first, to provide some brief background information on water resource legislation and agency structure in both the USA and the UK (for subsequent discussion in this chapter and others that follow); second, by looking briefly at the rationale underlying freshwater conservation; and third, to review opinions on which characteristics of rivers and lakes confer 'value' for conservation.

Legislation and agency structure in the USA and the UK

Clearly, socio-political and economic factors have helped shape approaches to conservation in both countries and are reflected by differences in legislation and the structure and mission of governmental and non-governmental agencies.

Legislative instruments relevant to freshwater conservation

The following sections summarize the principal legislative instruments relevant to freshwater conservation in the UK and the USA, including some that apply at a global or European level.

Ramsar Convention

The 'Convention on Wetlands of International Importance especially as Waterfowl Habitat' was signed in Ramsar, Iran, in 1971, and came into force in 1976. As of October 2008 there were 158 Contracting Parties with 1801 Ramsar sites covering 163×10^6 ha. The primary aim of the Convention is 'to stem the progressive encroachment on and loss of wetlands now and in the future' (www.jncc.gov.uk/legislation/conventions/ramsar.htm; www.ramsar.org). As its name implies, its focus is on water birds, although the criteria for selecting Ramsar sites now include other aspects of wetland conservation. The definition of a 'wetland' is a broad one: 'For the purpose of this Convention wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres', and that wetlands 'may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands'.

There are eight criteria for evaluating wetlands for designation as Ramsar sites. These state that a wetland should be considered internationally important if it

- contains a representative, rare or unique example of a natural or near natural wetland type found within the appropriate biogeographic region;
- supports vulnerable, endangered or critically endangered species or threatened ecological communities;
- supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region;
- supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions;
- regularly supports 20 000 or more water birds;
- supports 1% of the individuals in a population of one species of water bird;
- supports a significant proportion of indigenous fish that contribute to global biological diversity;
- is an important source of food for fishes, or a spawning ground, nursery and/or migration path that fish stocks depend on. (www.ramsar.org/key_criteria.htm, 2004).

Convention on Biological Diversity

The Convention on Biological Diversity (CBD) was adopted at the Earth Summit in Rio de Janeiro, in June 1992 (www.biodiv.org). The objectives of the Convention are 'the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources'. In addition, the signatories committed themselves to achieve by 2010 a significant reduction in the current rate of biodiversity loss at a global, regional and national level.

The CBD was initially signed by 157 governments, including the UK, with the USA signing a year later. At the time of writing (September 2007), 189 countries are party to the convention. As a demonstration of its commitment, the UK government rapidly responded by developing the UK Biodiversity Action Plan (BAP) (www.ukbap.org.uk/). This contains lists of priority species and habitats with target-based action plans. Many Local BAPs (LBAPs) have also been developed and implemented, and a computerized National Biodiversity Network (NBN) has been set up. The original UK BAP has recently been reviewed and in 2007 a revised list of 1149 priority species (double the original number) and 65 priority terrestrial, freshwater and marine habitats were identified. The current freshwater priority habitats are oligotrophic and dystrophic lakes, mesotrophic lakes, eutrophic standing waters, aquifer-fed naturally fluctuating water bodies, ponds and rivers. The CBD is given statutory backing in the UK through the Natural Environment and Rural Communities Act 2006 and the Nature Conservation (Scotland) Act 2004.

EC Habitats and Birds Directives

To implement the Bern Convention in Europe, the European Community adopted Council Directive 79/409/EEC on the Conservation of Wild Birds (the EC Birds Directive) in 1979, and Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the EC Habitats Directive) in 1992. The Birds Directive provides a framework for the conservation and management of wild birds in Europe, while the objective of the Habitats Directive 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' (Article 2). One of the principal means of achieving these aims is by establishing a coherent European network of protected areas, designed to maintain the distribution and abundance of threatened species and habitats. This network (Natura 2000) comprises Special Areas of Conservation (SACs) designated under the Habitats Directive, and Special Protection