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# The Wetland Book

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Editors

# The Wetland Book

I: Structure and Function, Management,  
and Methods

With 369 Figures and 74 Tables

 Springer

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## Foreword: The Wetland Book

The venerable lineage of encyclopedic publishing can be traced back to Pliny the Elder's *Naturalis Historia*, which contained chapters on water and aquatic life. Although our terminology regarding and understanding of the aquatic environment has evolved over the past two millennia, one constant has been the need for a multidisciplinary approach to examining these areas. Using an encyclopedic model, this multidisciplinary book builds on an ancient format and adapts it for a modern audience. In this way, *The Wetland Book* builds on a long tradition of scholarly publishing and presents invaluable information for its modern audience.

Wetlands have been around longer than the traditions associated with academic publishing. Wetland management and wise use have been practiced by indigenous cultures in many forms for millennia, and that ancient knowledge about wetlands was often curated and passed down orally or in traditional systems and forms. In modern times, the pressures and threats to wetlands are vastly different in their scope and magnitude. The forms of governance and administration that respond to these pressures and threats have also changed, particularly in their scale as it has been recognized that management takes place up to the level of countries and river basins, rather than simply at the local level.

Internationally, wetland conservation, management, and wise use are promoted through the Ramsar Convention on Wetlands. The countries that have signed onto the Ramsar Convention have recognized the imperatives to work with stakeholders and decision makers beyond the traditional wetland community and to incorporate wetlands into policy-making in other sectors such as water, energy, agriculture, and health. Indeed, in 2008 at the 10th Conference of the Contracting Parties of the Ramsar Convention, the Changwon Declaration was adopted, which contains key messages for wetland conservation, management, and wise use addressed to planners; policymakers; elected officials; managers in the environmental, land, and resource-use sectors; educators and communicators; economists; and health workers. *The Wetland Book* offers a base of knowledge that is intended to reach a similarly broad audience.

The editors and contributing authors to *The Wetland Book* have long experience and deep understanding of wetland science and management. Many have worked with the Ramsar Scientific and Technical Review Panel (STRP), the Convention's scientific advisory body, over the years. This collection of people provides a

repository of knowledge that can help meet the challenge of learning about and understanding the value of protecting and managing wetlands.

Making this knowledge more easily accessible, however, has always been difficult. There are physical limitations to how much we can pick a person's brain, and there are limitations to how much a wetland manager out in the field, perhaps with little technical support, can search for, read, and review scientific and traditional knowledge to find answers to pressing questions. Thus, the encyclopedic style of publication remains a viable format for accessing high levels of expertise, including expertise from distant locations with similar landscape and ecological characteristics. *The Wetland Book* provides an in-depth level of knowledge in the form of a handbook to assist those seeking information on the many facets of wetland management.

Of course, reading *The Wetland Book* will not make an individual an expert in all aspects of wetland science, wise use, and governance, a feat which no one publication can deliver. Instead, a truly useful publication should offer an individual the vocabulary to support further inquiry and to find knowledge that is locally, regionally, nationally, or even internationally applicable. It should also allow a reader to know who to ask and what questions to pursue when she or he needs more knowledge to solve a research question or particular management problem. *The Wetland Book* delivers this foundation through two volumes – Vol. 1: Structure and Function, Management, and Methods and Vol. 2: Distribution, Description, and Conservation.

We highly recommend *The Wetland Book*; it provides an unparalleled source of knowledge about wetlands by building on the ancient form of the encyclopedia, revitalized by new technologies for distribution and access. We are also proud to see that many of those who have contributed to the Ramsar Convention over many years or even decades have also contributed their knowledge and wisdom to *The Wetland Book*. Given our personal association with the convention, we also recognize the incredible contribution that the Convention has made to wetland knowledge and look forward to further contributions.

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## Preface

*The Wetland Book* is a hard copy and online production that provides an unparalleled collation of information on wetlands. It is global in scope and contains 462 chapters prepared by leading wetland researchers and managers. The wide disciplinary and geographic scope is a unique feature and differentiates *The Wetland Book* from the existing wetland literature. The editors have compiled *The Wetland Book* from contributions supplied by authors from many countries and disciplines. Combined, these chapters represent a global source of knowledge about wetlands. Given the number of chapters and the scope of the content, it has been published as two separate books.

The bibliographic detail of two books is given below. Book 1 with 292 chapters covers the structure and function of wetlands, as well as the management and the methods used to investigate them.

The Wetland Book I: Structure and Function, Management, and Methods: edited by Finlayson CM, Everard M, Irvine K, McInnes RJ, Middleton BA, van Dam AA and Davidson NC.

Its companion book, published separately, with 170 chapters is:

The Wetland Book II: Distribution, Description, and Conservation: edited by Finlayson CM, Milton GR, Prentice RC and Davidson NC.

*The Wetland Book* was developed following discussions with wetland experts from the Scientific and Technical Review Panel of the Ramsar Convention on Wetlands and from the Society for Wetland Scientists. These experts pointed to the rapidly expanding literature on wetlands and enthusiastically proposed the development of a comprehensive information resource aimed at supporting the trans- and multidisciplinary research and practice, which is essential to wetland science and management. They were also seeking an information resource that would both complement and extend the existing literature and in particular provide a compendium of knowledge with contributions from authors around the world.

Aware that wetland research was on the rise and that wetland researchers and practitioners often needed to work across disciplines, *The Wetland Book I* has been prepared to serve as a first port of call for those interested in the key concepts in wetland science and management. This approach was taken to allow individuals and multi- and transdisciplinary teams to search for particular terms and subjects, access further details, and read overviews of topics selected by the editors and expert authors. The content provides a global coverage of wetland knowledge with chapters provided by leading wetland experts with information that spans local and regional issues to the wider body of science that is needed to assist practitioners and enable students to come to grips with one of the world's most diverse and important set of ecosystems. This content is especially important as wetland ecosystems in many parts of the world are under increasing pressure due to degradation from human development, which continues at an alarming rate and will require more effective management and restoration. It draws heavily on knowledge compiled through the formal processes of the Ramsar Convention and associated programs and extends upon information contained in the seminal global assessment of wetlands undertaken through the Millennium Ecosystem Assessment.

Book I is organized in three parts, Wetland Structure and Function (coordinated by B.A. Middleton); Wetland Management (coordinated by M. Everard and R.J. McInnes); and Wetland Methods (coordinated by A.A. van Dam and K. Irvine). Each part is divided into thematic sections with one or more overview chapters, supported by articles and case studies providing further information on different aspects of the theme. Each section was developed and collated by section leads, namely M. Acreman, M. Alexander, J.A. Boudell, N.C. Davidson, M. Demissie, M. Everard, C.M. Finlayson, P. Gerbeaux, R. Kumar, R. Lucas, R.J. McInnes, B.A. Middleton, D. Moreno Mateos, R. Slootweg, K. Stevens, and C. Stratford. For Wetland Structure and Function, there are chapters covering: succession; biological adaptations; ecological processes and biogeochemistry; importance of hydrology to wetlands; and landscape ecology. For Wetland Management, there are chapters covering: an overview of wetland management; the international framework for wetland conservation and wise use; wetland law and policy; and management of ecosystem services. For Wetland Methods, the chapters cover: wetland delineation and classification; Earth observation approaches and their application to wetland ecosystems; wetland monitoring and assessment; environmental flows; wetland management planning; wetland restoration and creation; environmental impact assessment; strategic environmental assessment; and economic valuation.

We warmly convey our special thanks to those who have acted as section leads and to all the many authors who gave their time and knowledge of wetlands to support this effort as well as their patience while the large number of chapters were collated and edited. We are proud to have worked with them to produce this book. With the benefit of their unstinting efforts and incredibly rich knowledge, *The Wetland Book I* provides a comprehensive source of information for wetland researchers, students, and practitioners. It specifically provides a much needed information resource to support the many efforts to ensure the wise use of wetlands

globally. It has not only drawn on but also extended the expert guidance and advice that the Ramsar Convention's Scientific and Technical Review Panel has provided for governments and wetland experts alike for almost 25 years. In this respect, the foreword provided by the past and present chairs of the panel is particularly appreciated. In providing the foreword, they have reflected on the wealth of knowledge collated by wetland experts who have worked tirelessly to provide government officials with the knowledge base needed to ensure the conservation and wise use of wetlands around the world.

As editors for *The Wetland Book I*, we personally compliment the many contributors and extend a huge vote of gratitude to our section leads for their incredible contributions to the most comprehensive compendium of knowledge about wetlands ever assembled. In particular, we commend their contributions to the wetland literature and acknowledge their unstinting efforts to compile the many chapters and work with the authors to produce *The Wetland Book*. Their knowledge and efforts are matched by their willingness to share the collated knowledge that is now contained in the *The Wetland Book*.

The publisher is thanked for their foresight in developing the concepts that led to *The Wetland Book* and for providing both a hard copy and online version, with the latter being available for future updating. We recommend *The Wetland Book* to all those interested in the growing international knowledge about wetland science and management of these incredibly valuable but threatened ecosystems.

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**Max Finlayson** is an internationally renowned wetland ecologist with extensive experience internationally in water pollution, agricultural impacts, invasive species, climate change, and human well-being and wetlands. He has participated in global assessments such as those conducted by the Intergovernmental Panel for Climate Change, the Millennium Ecosystem Assessment, and the Global Environment Outlook 4 and 5 (UNEP). Since the early 1990s, he has been a technical adviser to the Ramsar Convention on Wetlands and has written extensively on wetland ecology and management. He has also been actively involved in environmental NGOs and from 2002 to 2007 was president of the governing council of global NGO Wetlands International.

Professor Finlayson has worked extensively on the inventory, assessment, and monitoring of wetlands, in particular in wet tropical, wet-dry tropical, and subtropical climatic regimes covering pollution, invasive species, and climate change. His current research interests/projects include the following:

- Interactions between human well-being and wetland health in the face of anthropogenic change, including global change and the onset of the Anthropocenic era
- Vulnerability and adaptation of wetlands/rivers to climate change, including changing values and trade-offs between uses and users, considering uncertainty and complexity
- Integration of ecologic, economic, and social requirements and trade-offs between users of wetlands with an emphasis on developing policy guidance and institutional changes
- Environment and agriculture interactions and policy responses/outcomes, and collaboration between stakeholders and policymakers

- Wetland restoration and construction, including the use of artificial wetlands for waste water treatment and the generation of multiple values
- Landscape change involving wetlands/ivers and land use (agriculture and mining) and implications for wetland ecosystem services and benefits for local people

He holds the following associated positions

- Scientific Expert on the Scientific and Technical Review Panel, Ramsar Convention on Wetlands, Triennium 2016–2018
- Ramsar Chair for the Wise use of Wetlands, UNESCO-IHE, Delft, The Netherlands (2014–2018)
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- Editor-in-Chief, Marine and Freshwater Research, CSIRO Publishing
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Professor Finlayson has contributed to over 300 journal articles, reports, guidelines, proceedings, and book chapters on wetland ecology and management. He has contributed to the development of concepts and methods for wetland inventory, assessment and monitoring, and undertaken many site-based assessments in many countries.



**Mark Everard**

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**Mark Everard** is associate professor of Ecosystem Services at the University of the West of England (UWE, Bristol) in the UK, as well as a consultant, author, and broadcaster.

Mark has extensive involvement in the development and implementation of ecosystem services and the ecosystem approach since the 1980s. He has particular interests in wetland and water systems, including the many important roles they play in socioecological systems and sustainable or other feedback between human and natural elements of these systems.

Mark's work has included extensive international development work, principally in Africa and India, exploring and helping people optimize their interdependencies with wetlands. He has also served as a policy adviser to UK government around ecosystem and environmental issues, as well as to governments in South Africa, India, and Sri Lanka. However, as the formal policy environment is only as strong as its influence and enforcement, Mark has also worked at local and regional scales particularly in developing countries to learn and out-scale social processes that develop sustainable relationships between people and water resources.

Mark's academic involvement has been extensive, including his most recent role at UWE, and he has also been involved in trustee and advisory capacities with many



environmental NGOs. Mark is also a prolific communicator, writing many books, academic papers, and magazine articles targeting a range of scientific, technical, and popular audiences, also making regular contributions to TV, radio, and online media.



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**Kenneth Irvine**, born in Dublin, has worked on a range of lakes and catchments in Europe and Africa, gaining broad experience of the global challenges facing water and habitat quality. After gaining a Ph.D. in 1987 at the University of East Anglia (UK) for a study on shallow lake food webs, he worked as a nature conservation

officer for the UK Nature Conservancy Council, before moving to study ecosystem structure and estimating the secondary production of Lake Malawi in Africa. From there, in 1994 he moved to Trinity College Dublin, Ireland, and spent a decade and a half grappling with the intricacies of policy and ecology to support the implementation of the EU Water Framework Directive. His alter ego continued to work on the African Great Lakes of Malawi and Tanganyika, and the ecology of the Makgadikgadi salt pans of Botswana. In 2011, he moved to UNESCO-IHE Institute of Water Education in the Netherlands to engage more fully in research and teaching to support capacity development. He heads up the Aquatic Ecosystems Group and their work on, mainly, African wetlands, with other recent work on the capacity development within the Danube basin and for Integrated Water Resource Management in India and Southeast Asia. He continues to learn about the complexities and wicked problems of sustainable use of water and ecosystems.



**Robert J. McInnes**

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**Robert McInnes** is an independent chartered environmentalist with over 25 years' experience in wetland-related environmental research, consultancy, and conservation. His main areas of interest in wetlands revolve around three inter-related themes: understanding their biodiversity and the ecosystem services provided to human society; the practical restoration and creation of wetlands for multifunctional benefits; and the development and implementation of wetland conservation and wise use policies and strategies.

He works on wetland-related projects within the UK and overseas and has knowledge extending across a range of wetland types. He regularly publishes articles in peer-reviewed journals, books, and conference proceedings. Prior to working independently, Rob was head of Wetland Conservation at the Wildfowl and Wetlands Trust, UK, and has also worked in ecological consultancy and in academia at the universities of Exeter and London.

Rob has been actively involved with the Ramsar Convention's Scientific and Technical Review Panel since 2008 where he has contributed to the Panel's work on urban wetlands, wetland restoration, wetlands and climate change, and wetland ecosystem services. In addition to undertaking projects on behalf of the Ramsar Convention Secretariat, he has worked for intergovernmental organizations, including UNESCO, CBD, and UN HABITAT, major international NGOs, national and local governments, and private clients.

In addition to his project work, Rob is an active member of the Society of Wetland Scientists (SWS), has been a former president of the European Chapter of SWS, is an associate editor of the society's journal *Wetlands*, and in 2011 was awarded the President's Service Award for the significant contributions he has made in promoting the goals of the society.



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**Beth Middleton** is a research ecologist with the US Geological Survey's Wetland and Aquatic Research Center in Lafayette, USA. Her biogeographical research focuses on the impact of climate and landuse change on wetlands, particularly forested freshwater wetlands. Her most recent studies are on hydrologic remediation and vegetation response, and she applies those findings to natural resource conservation. Her work has contributed to the understanding of world wetland restoration and global climate change and her book *Wetland Restoration, Flood Pulsing, and Disturbance Dynamics* received the Merit Award of the Society of Wetland Scientists. Her dissertation was on monsoonal wetlands in India (Ph.D. Iowa State University) and was the origin of her later research on the implications of shifts in drought cycles on wetland biodiversity. Her writing is extensive with several books and more than 125 research articles.

She is a member of the graduate faculty at the University of Louisiana and an adjunct professor at Louisiana State University. Before moving to USGS, she was a full professor at Southern Illinois University. Currently, she is a member of several climate change advisory committees and management working groups. She has done extensive research on worldwide wetlands including monsoonal wetlands, baldcypress swamps, peatlands, salt marshes, fens, and mangrove swamps. She is a fellow of the National Conservation Leadership Institute. Her Fulbright work was at G.B. Pant University. She has served as a senior visiting professor with the

Chinese Academy of Science working on wetland dynamics in China and is a Sigma Xi Distinguished Lecturer. Also, she has given several high level addresses including the Earth Day talk for the US Consulate in Chennai, India, and a TEDx talk called “Conservation Oblivion” ([www.youtube.com/watch?v=8O72jOgTQPw](http://www.youtube.com/watch?v=8O72jOgTQPw)).



**Anne A. van Dam**

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**Anne van Dam** is associate professor of Environmental Systems Analysis at the UNESCO-IHE Institute for Water Education in Delft, the Netherlands. He holds a Ph.D. in Agricultural and Environmental Sciences (1995) from Wageningen University in the Netherlands. Before joining UNESCO-IHE in 2003, he worked for the International Center for Living Aquatic Resources

Management (ICLARM) and for Wageningen University, in various aquaculture and fisheries research projects in the Netherlands, South and Southeast Asia, Africa, and Latin America. His research interests are in the areas of sustainable aquatic resource management, freshwater wetland ecology and governance, nutrient dynamics, and ecosystems modeling. His publications cover subjects like fish growth modeling, periphyton-based fish production systems, integrated agriculture-aquaculture systems, and wetland ecosystem services. During the last 10 years, he had a leadership role in research and capacity development projects in East Africa, with research focusing on the interactions between livelihood activities (e.g., agriculture) and the ecological functioning of papyrus wetlands, collaborating with universities, government agencies, and NGOs in Kenya, Uganda, and Rwanda. He has represented UNESCO-IHE at the Scientific and Technical Review Panel (STRP) of the Ramsar Convention, is an executive editor of the international journal *Aquaculture Reports*, and was guest editor of a special issue of *Wetlands Ecology and Management* on the ecology and livelihoods of papyrus wetlands.



**Nick C. Davidson**

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**Nick Davidson** was the deputy secretary general of the Ramsar Convention on Wetlands from 2000 to 2014, with overall responsibility for the convention’s global development and delivery of scientific, technical, and policy guidance and advice and communications as the Convention Secretariat’s senior advisor on these

matters. He has long-standing experience in, and a strong commitment to, environmental sustainability supported through the transfer of environmental science into policy-relevance and decision-making at national and international scales. Nick currently works as an independent expert consultant on wetland conservation and wise use.

Nick has over 40 years' experience of research on the ecology, assessment, and conservation of coastal and inland wetlands and the ecophysiology and flyway conservation of migratory waterbirds, with a 1981 Ph.D. from the University of Durham (UK) on this topic, and continues to publish on these issues. Prior to his Ramsar Convention post, he worked for the UK's national government conservation agencies on coastal wetland inventory, assessment, information systems, and communications and as international science coordinator for the global NGO Wetlands International.

He is an adjunct professor at the Institute of Land, Water and Society, Charles Sturt University, Australia; was presented with the Society of Wetland Scientist's (SWS) International Fellow Award 2010 for his long-term contributions to global wetland science and policy; chairs the SWS's Ramsar Section; is an associate editor of the peer-reviewed journal *Marine & Freshwater Research*; is a member of several IUCN Commissions and their task forces (World Commission on Protected Areas (WCPA), Species Survival Commission (SSC), and Commission on Ecosystem Management (CEM)); and is an honorary fellow of the Chartered Institution of Water and Environmental Management (CIWEM).

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