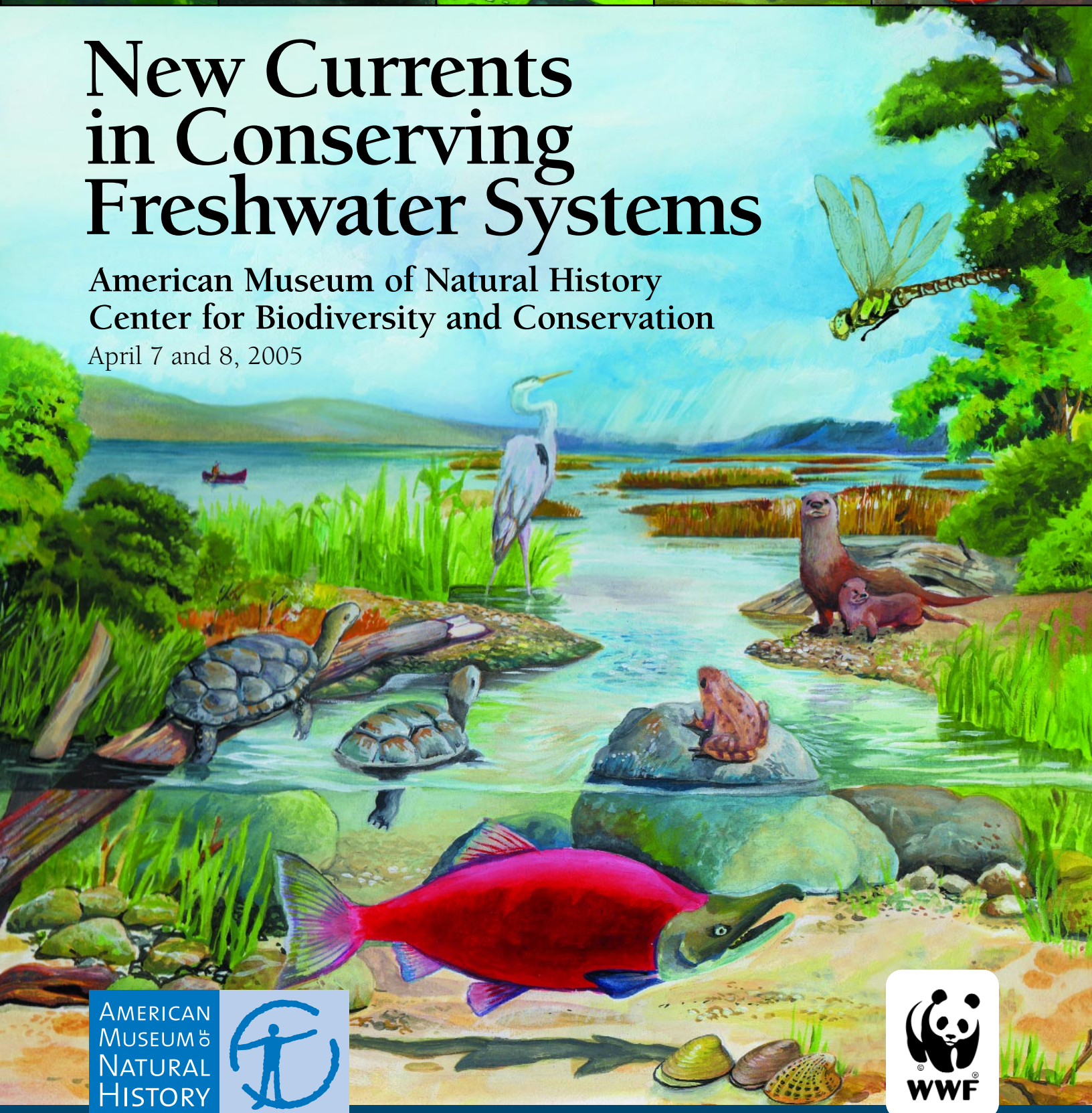
SPRING SYMPOSIUM

New Currents in Conserving Freshwater Systems

American Museum of Natural History
Center for Biodiversity and Conservation

April 7 and 8, 2005



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New Currents in Conserving Freshwater Systems

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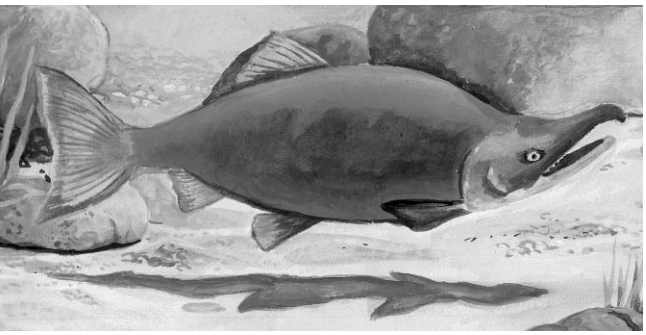
Support for *New Currents in Conserving Freshwater Systems* is provided by Daniel and Sheryl Tishman, and the Mack Lipkin Man and Nature Lecture Series.



Additional support is provided by The Conservation Trust of the National Geographic Society, the American Society of Ichthyologists and Herpetologists, The Nature Conservancy, and the American Fisheries Society.

The Center for Biodiversity and Conservation was established with a leadership grant from The Starr Foundation and the support of many other generous foundations, corporations, and individuals.

Many people contributed to the planning and execution of this symposium, and while they are far too numerous to list individually, the Center for Biodiversity and Conservation extends its thanks to all of them.

For their significant role in shaping the form and content of this symposium, we especially wish to acknowledge the members of the symposium's steering committee and content advisors, who are named on the back page of this program.

We also wish to acknowledge the valuable contributions of Nancy Dammann Davis, Michele Thieme, John Sparks, Scott Schaefer, Erin McCreless, Julie Pomerantz, Tara Corseri, Jeanne McCarthy, Jason Ross, and Adam Cherson.

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This program was prepared by the Center for Biodiversity and Conservation under award NA04OAR4700191 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

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NEW CURRENTS IN CONSERVING FRESHWATER SYSTEMS

SPRING SYMPOSIUM

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Note: Additional symposium information, including speaker publications lists and suggested freshwater resources, can be accessed via the CBC website at www.cbc.amnh.org

An archived transcript of the symposium presentations will also be available online in the coming months.

American Museum of Natural History

NEW CURRENTS IN CONSERVING FRESHWATER SYSTEMS

SPRING SYMPOSIUM

Freshwater rivers, lakes, wetlands, springs, and groundwaters are home to an astounding wealth of life — tens of thousands of species of fish, invertebrates, reptiles, amphibians, birds, and mammals. These species are besieged by an array of threats ranging from the local to the global — dams, the invasion of exotic species, overfishing, pollution, stream channelization, water extraction and diversion, and the panoply of impacts linked to development of the terrestrial landscape. Across the world, freshwater habitats and species are among the most imperiled components of global biodiversity.

Freshwater systems sustain *all* life, including human communities. While conserving the ecological integrity of these vital systems is a critical goal, it remains elusive. Dedicated scientists and managers have worked for decades to improve the health of freshwaters, yet in most places the outcome is far from certain. There is an urgent need to develop and apply innovative, science-based approaches to freshwater biodiversity conservation, and to share success stories.

Because human activities are so closely tied to freshwater systems, conservation of the biodiversity within those systems faces a set of unique challenges. Working with users of water — local communities, industries, farmers, and others — to develop and implement sustainable solutions that meet the needs of both people and freshwater species is a basic foundation of many successes. Infusing these collaborations with the best science, even in the most data-poor situations, is integral to defining and achieving sustainability. Innovations in generating and applying that science represent an important conservation frontier.

Just as freshwater biodiversity conservation must transcend "hard" science to include social, cultural, economic, and political considerations, so too does freshwater biodiversity science need to extend beyond biology. There is no doubt that strong biological information underpins effective conservation. But physical sciences like hydrology are equally important to the design and application of integrative conservation solutions. Bringing together scientists with shared interests and different disciplinary backgrounds to form working partnerships will be crucial to the next generation of freshwater conservation achievements.

This symposium provides a forum for these interdisciplinary and international exchanges. Experts from around the world — researchers and practitioners with a range of experiences — will explore new collaborations and ideas for enhancing the effectiveness of their conservation efforts. Whether innovations take the form of new scientific tools or improved methods for applying existing ones, the urgency of conserving freshwater biodiversity requires that we immediately embrace the best ideas and put them into action.

A Biodiversity Science Symposium
American Museum of Natural History
Kaufmann and Linder Theaters

DAY ONE
THURSDAY, APRIL 7, 2005

7:30 – 8:30 a.m. REGISTRATION

SESSION I
INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

8:30 a.m. – 12:05 p.m.

INTRODUCTORY REMARKS

MICHAEL J. NOVACEK, *Senior Vice President and Provost of Science, American Museum of Natural History, USA*

ELLEN V. FUTTER, *President, American Museum of Natural History*

Moderator: **DAN ASHE**, *Science Advisor to the Director, U.S. Fish and Wildlife Service, Department of Interior, USA*

KEYNOTE ADDRESS

Innovations Around the World: What Do We Need, and Why?

MELANIE L.J. STIASSNY, *Axelrod Research Curator, Department of Ichthyology, American Museum of Natural History, USA*

Pantanal: Driving Forces and Terrestrial-Freshwater Interactions

WOLFGANG J. JUNK, *Scientist, Max Planck Institute for Limnology, Working Group Tropical Ecology, Germany*

Bridging Troubled Waters — Taxonomic Science in the Service of Freshwater Fish Conservation in South Africa

PAUL SKELTON, *Managing Director, South African Institute for Aquatic Biodiversity, South Africa*

BREAK (20 minutes)

Use of Genetic Tools to Examine Regional Patterns of Biodiversity

DAVID J. BERG, *Professor of Zoology, Miami University, Ohio, USA*

Videography of Subsurface Aquatic Life — A Useful Procedure to Make Environmental Conservation of Subterranean Animals Attractive: The Lobau Wetlands (Austria) Experience

DAN DANIELOPOL, *Senior Scientist, Austrian Academy of Sciences, Institute of Limnology, Austria*

Imperiled Giants of the Mekong

ZEB HOGAN, *Aquatic Ecologist, University of Wisconsin, USA*

Remote Sensing of Freshwaters to Support Conservation Efforts

STEPHEN K. HAMILTON, *Associate Professor of Zoology, W.K. Kellogg Biological Station, and Department of Zoology, Michigan State University, USA*

12:05 – 1:15 p.m. LUNCH BREAK

SESSION II
INNOVATIONS IN PLANNING FOR CONSERVATION

1:15 – 5:25 p.m.

Moderator: **FELICITY ARENGO,** *Associate Director, Center for Biodiversity and Conservation, American Museum of Natural History, USA*

Water Snakes, Livelihoods, and Conservation: Tonle Sap, Cambodia

SHARON BROOKS, *School of Biological Sciences, University of East Anglia, UK*

Macro- and Micro-Scale Circulation Modeling in the Mesopotamian Marshlands of Southern Iraq

AZZAM ALWASH, *Director, Eden Again Project, Iraq*

Freshwater Ecosystems and Mobile Species in Australia: Is Conservation Possible When Current Models for River Conservation are Poor?

Richard Kingsford, *Professor of Environmental Science, School of Biological, Earth and Environmental Science, University of New South Wales, Australia*

Counting Ecosystems as Part of Development Infrastructure — Using Economic Valuation to Promote Freshwater Biodiversity Conservation in Africa

Lucy Emerton, *Regional Group Head, Asia Ecosystems and Livelihoods Group, IUCN-The World Conservation Union, Sri Lanka*

Break (20 minutes)

Irrawaddy Dolphins and Cast-Net Fishermen: A Conservation Partnership in the Ayeyarwady River, Myanmar

Tint Tun, Brian D. Smith, and Mya Than, *Associate Marine Biologist, Wildlife Conservation Society, Myanmar; Wildlife Conservation Society, Southeast Asia; Myanmar Department of Fisheries*

Conserving Wetland Network Across Borders in the Altiplano

Patricia Marconi, *Fundación YUCHAN, Argentina,* and
Sandra M. Caziani, *Facultad de Ciencias Naturales, Universidad Nacional de Salta-CONICET, Argentina*

Alternative Future Analysis in the Willamette River Basin

Stanley Gregory, *Professor, Department of Fisheries and Wildlife, Oregon State University, USA*

Hydrology for the World: New Data, Tools, and Applications

Bernhard Lehner, *Freshwater GIS Specialist, Conservation Science Program, World Wildlife Fund, USA*

PANEL DISCUSSION: LAYING THE GROUNDWORK FOR FRESHWATER CONSERVATION — WHAT CHARACTERIZES INNOVATIONS AND SUCCESSES?

Moderator: **Robin Abell,** *Freshwater Conservation Biologist, Conservation Science Program, World Wildlife Fund, USA*

Dan Ashe, *Science Advisor to the Director, U.S. Fish and Wildlife Service, Department of Interior, USA*

William Darwall, *Freshwater Biodiversity Assessment Programme Head, IUCN Species Programme, UK*

Melanie L.J. Stiassny, *Axelrod Research Curator, Department of Ichthyology, American Museum of Natural History, USA*

David L. Strayer, *Aquatic Ecologist, Institute of Ecosystem Studies, USA*

The 2005 Mack Lipkin Man and Nature Series Lecture

5:30 p.m.

The Fish and Wildlife Service and Freshwater Biodiversity: A Focus on Partnerships and an Eye on the Future

Mamie Parker, *Assistant Director for Fisheries and Habitat Conservation, U.S. Fish and Wildlife Service, USA*

The Mack Lipkin Man and Nature Series Reception

6:15 – 8:30 p.m.
Hall of Northwest Coast Indians

Poster Session

6:30 – 8:30 p.m.
Hall of Northwest Coast Indians

A Biodiversity Science Symposium
American Museum of Natural History
Kaufmann and Linder Theaters

DAY TWO
FRIDAY, APRIL 8, 2005

SESSION III
INNOVATIONS IN PUTTING PLANS INTO PRACTICE

8:30 a.m. – 12:50 p.m.

INTRODUCTION

IAN HARRISON, *Research Assistant, American Museum of Natural History Department of Ichthyology, and Project Coordinator for the Center for Biodiversity and Conservation, American Museum of Natural History, USA*

The Water Resources Development Community: What Does It Need to Know?

Speaker **TBA**

Moderator: **DAVID P. BRAUN,** *Senior Watersheds Biohydrologist and Director, Agricultural Watersheds Initiative, Upper Mississippi River Program, The Nature Conservancy, USA*

Conservation of the Freshwater Biodiversity of Sri Lanka

ROHAN PETHIYAGODA, *Founder, Wildlife Heritage Trust of Sri Lanka*

Fly Fishing for Biodiversity: Taimen in Mongolia

JAKE VANDER ZANDEN, *Assistant Professor, University of Wisconsin – Madison, Center for Limnology, USA*

Environmental Flow Assessment: Issues and Innovations

REBECCA THARME, *Freshwater Ecologist, International Water Management Institute, Sri Lanka*

BREAK (20 minutes)

Subterranean Animals in Slovenia: Protecting Habitats, Not Specimens

BORIS SKET, *Professor of Zoology and Speleobiology, University of Ljubljana, Slovenia*

Turning Back the Clock: Restoring Lake Ecosystems by Eradicating Introduced Fish

ROLAND KNAPP, *Research Biologist, Sierra Nevada Aquatic Research Laboratory, University of California, USA*

Community-Based Management of Pirarucu in Mamirauá, Amazon, Brazil

LEANDRO CASTELLO, *Mamirauá Sustainable Development Institute, Brazil, and College of Environmental Science and Forestry, State University of New York, USA*

Communities and Catchment Strategies for Freshwater Management: Selected Examples from Around the World

CAROLINE SULLIVAN, *Head of Water Policy and Management, Centre for Ecology and Hydrology, UK*

12:50 – 2:20 p.m. LUNCH BREAK

SESSION IV
INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

2:20 – 6:00 p.m.

Moderator: **CHARLES P. HAWKINS,** *Director, Western Center for Monitoring and Assessment of Freshwater Ecosystems, Utah State University, USA*

A Bottom-Up Approach to Monitoring, Conserving, and Managing in the Orange-Vaal River Basin, South Africa

PIERRE DE VILLIERS, *Environmental Affairs Directorate, Department of Tourism, Environmental and Economic Affairs, Free State Province, South Africa*

The Mighty Duck: Using Dams to Restore Imperiled Species

Paul Johnson, *Director, Tennessee Aquarium Research Institute,* and
Steven A. Ahlstedt, *Biologist, U.S. Geological Survey, USA*

From Thriving Wetland to Saline Desert and Back: Floods for Restoration in Hostile Lands

Olivier Hamerlynck, *Former Advisor, IUCN Wetlands and Water Resources Programme*

Ecological Impact of Small Dam Removal

Karen Bushaw-Newton, *Assistant Professor, Microbial Ecology & Biogeochemistry, American University, USA*

Break (20 minutes)

Project Piaba: Evaluating Success in Aquatic Conservation through a Sustainable Ornamental Fishery in the Amazon Basin

Ning Labbish Chao, *Universidade Federal do Amazonas, Brazil*

The U.S. Clean Water Act: Innovative National Legislation Guiding Local and Regional Freshwater Biodiversity Conservation

Ed Rankin, *Senior Research Associate, Center for Applied Bioassessment & Biocriteria, USA*

Community Monitoring of Wetlands at Multiple Scales

Max Finlayson, *Principal Researcher, International Water Management Institute, Sri Lanka*

PANEL DISCUSSION: WHAT CAN WE LEARN FROM INNOVATIONS?

Moderator: **Eleanor J. Sterling,** *Director, Center for Biodiversity and Conservation, American Museum of Natural History, USA*

Edward Allison, *Senior Lecturer in Natural Resources, School of Development Studies, University of East Anglia, UK*

Xanthippe Augerot, *Director of Science, Wild Salmon Center, USA*

Carmen Revenga, *Senior Freshwater Scientist, Habitat Assessment Team, Global Priorities Group, The Nature Conservancy, USA*

Brian Richter, *Director, Freshwater Initiative, The Nature Conservancy, USA*

Conference Adjourns

Robin Abell

Freshwater Conservation Biologist, Conservation Science Program, World Wildlife Fund-USA

Robin Abell is a senior freshwater conservation biologist at World Wildlife Fund (WWF) and directs that organization's freshwater science efforts. She has been at WWF for eight years, during which time she has been engaged in conservation research and planning efforts at global, continental, and ecoregional scales. She is lead author of *Freshwater Ecoregions of North America: A Conservation Assessment* (Island Press, 2000) and co-author of companion assessments for Latin America and the Caribbean and Africa. Currently, she is leading a worldwide assessment of freshwater biodiversity and threats to it. She also works with WWF field programs around the world, in places like the Amazon, Congo, and Mekong river basins, to develop ambitious, long-term plans for freshwater biodiversity conservation. Ms. Abell is coordinator of the Society for Conservation Biology's freshwater working group. She received her M.S. from the University of Michigan's School of Natural Resources and Environment and did her undergraduate work at Yale University.

Edward Allison

Senior Lecturer in Natural Resources, School of Development Studies, University of East Anglia, UK

Edward Allison is an interdisciplinary fisheries and aquatic resource management specialist based in the School of Development Studies, University of East Anglia, U.K. Originally trained as a marine biologist, he completed his Ph.D. on the population dynamics and fishery assessment of shellfish in the Irish Sea; after this, he made the gigantic conceptual leap into freshwater to work on a project investigating the fishery resource potential of Lake Malawi/Niassa. Subsequent leaps (or lurches) have been across even broader disciplinary divides and he now straddles the natural and social sciences — sometimes precariously. He works mostly on issues of poverty alleviation and vulnerability reduction among aquatic resource users. He has worked throughout Sub-Saharan Africa and in several Asian and South American countries on issues that include biodiversity conservation, community-based resource management, and vulnerability of fisherfolk to HIV/AIDS and to climate change.

Azzam Alwash

Director, Eden Again Project, Iraq

Macro- and Micro-Scale Circulation Modeling in the Mesopotamian Marshlands of Southern Iraq

Satellite imagery and on-the-ground surveys show that extensive diversion structures, built by the Iraqi Army, have desiccated 90% of the marsh area at the onset of hostilities in March 2003. Since then, the people of the marshes have breached dykes and floodgates, and up to 40% of the marshes have been inundated with water. Some areas have managed to recover, while others are slow in healing. In order to help the Iraqi government manage the limited amount of water available in the restoration process, the Eden Again team, along with the U.S. Army Corps of Engineers, is developing hydrodynamic circulation models for the marshes in order to have tools for the evaluation of restoration alternatives. Such models would examine the problem on two different scales. At the macro-scale level, it would be possible to examine the effects of varying inflows on the marsh ecosystem. The macro-scale analyses, however, would cover areas between tens and hundreds of square kilometers. On the other hand, at the micro-scale level, numerical analyses of circulation patterns would provide a means to evaluate alternative restoration plans. Simulation results have provided a preliminary look at overall circulation patterns arising from inflows/outflows to the system. Our analysis benefited from access to reasonably detailed topographic maps and exceptional satellite imaging products. This enabled us to include in our model most of the hydraulic structures that are responsible for causing the desiccation of the marshes. The model also provided the means to assess the effects of hypothetical water releases into the marshlands. The results of the macro-scale circulation model were used to develop micro-scale models for the Abu Zirig Marsh, a pilot project, at a more detailed level. The objective is to examine the interaction of marsh conditions (e.g., bathymetric features, vegetation, etc.) and hydrodynamic forcing (freshwater inflows, meteorology, salinity and temperature gradients, the presence of hydraulic structures, etc.). With the aid of newly acquired, highly accurate topographic data, the micro-scale analyses are providing insights on circulation patterns and velocity distributions and are applied to evaluate alternative restoration scenarios and to plan/design constructed wetlands to meet water treatment needs for villages in the region.

Azzam Alwash is the Director of the Eden Again Project. Born in Kut, Iraq in 1958, he spent much of his younger years in Nasseriya on the fringes of the marshlands. His father, Mr. Jawad Alwash, was the district irrigation engineer, and Azzam used to accompany him on trips into the marshlands to resolve water disputes. Dr. Alwash left Iraq in 1978 as a result of the Baathist regime, and completed his Bachelor of Science (Civil Engineering) at California State University at Fullerton, and his Ph.D. in Civil Engineering at the University of Southern California. Subsequently, he worked for 20 years as a soils and environmental engineering consultant in southern California. In 1998, he and his wife, Dr. Suzanne Alwash, a geologist, started Eden Again to try to put the spotlight on the environmental disaster caused by the drying of the marshes, in the hopes of putting pressure on the regime to flood the marshes. After liberation, Dr. Alwash quit his consultancy practice to direct the Eden Again operations in Iraq. He now lives permanently in Iraq, dividing his time between Baghdad, the marshlands, and international speaking engagements.

Felicity Arengo

Associate Director, Center for Biodiversity and Conservation,
American Museum of Natural History, USA

Felicity Arengo is the Associate Director of the Center for Biodiversity and Conservation where she helps oversee strategic planning, project development, and fundraising efforts. She is also adjunct professor at Columbia University. Dr. Arengo has over 10 years of field research and project experience in Latin America and is currently the Western Hemisphere co-ordinator of the IUCN Flamingo Specialist Group. She received an M.Sc. in 1987 and a Ph.D. in Wildlife Ecology in 1997 from the State University of New York College of Environmental Science and Forestry. For her doctoral dissertation she studied Caribbean Flamingo behavior and ecology in Mexico. Currently she is working with South American colleagues on flamingo and wetland research and conservation in the high Andes. Prior to joining the CBC in December 2004 Dr. Arengo was the Assistant Director of the Latin America and Caribbean Program at the Wildlife Conservation Society.

Dan Ashe

Science Advisor to the Director, U.S. Fish and Wildlife Service,
Department of the Interior, USA

Dan Ashe is the Science Advisor to the Director of the U.S. Fish and Wildlife Service. Previously, he served as the Chief of the National Wildlife Refuge System and as Assistant Director for Refuges and Wildlife, directing operation and management of the 93 million-acre National Wildlife Refuge System, land acquisition, and migratory bird and wetlands conservation programs. Mr. Ashe also served as the Fish and Wildlife Service's Assistant Director for External Affairs, directing the agency's legislative, communications, research, Native American, and state grant programs. From 1982 until 1995, Mr. Ashe was a Member of the Professional Staff of the former Committee on Merchant Marine and Fisheries in the U.S. House of Representatives, advising the Committee's Chairmen and Members on a wide range of environmental policy issues. Mr. Ashe earned degrees from the University of Washington and Florida State University.

Xanthippe Augerot

Director of Science, Wild Salmon Center, USA

David J. Berg

Professor, Department of Zoology, Miami University, Ohio, USA

Use of Genetic Tools to Examine Regional Patterns of Biodiversity

The Chihuahuan Desert of North America is home to many endemic species. This region's unique biological communities have led to its inclusion among the World Wildlife Fund's Global 200 ecoregions. Amphipods (Arthropoda: Crustacea) in the Gammarus pecos *species complex are endemic to spring systems in western Texas and eastern New Mexico. We examined patterns of genetic variation in this group; our results were used to consider taxonomic status of this species complex and biogeography of this region. Seven spring systems containing eleven populations were surveyed. Individual populations contained high levels of genetic variation; however the distribution of this variation suggested that two of the populations might each contain cryptic species. Preliminary behavioral and morphological observations support such an interpretation. Populations were highly differentiated, implying long periods of isolation with little gene flow. Genetic results were consistent with previously published morphological characteristics. At least four distinct species belong to this complex, including at least one undescribed species. Patterns of variation among populations of amphipods were similar to those found in other groups of desert spring animals. There appears to be a coherence to biogeographic patterns within the northern Chihuahuan Desert, likely arising from regional processes that shaped endemicity patterns in a variety of faunal groups. Knowledge of genetic structure and taxonomic status within the* G. pecos *complex provides insight into the biogeography of other aquatic organisms in these spring systems. These common patterns of variation suggest that conservation strategies that account for such patterns may simultaneously benefit multiple groups of organisms.*

David J. Berg is a professor of Zoology at Miami University in Ohio. Prior to joining Miami, he received a B.S. from the University of Notre Dame, an M.S. from Northwestern State University of Louisiana, and a Ph.D. from Ohio State University. His research utilizes genetic tools (allozymes, DNA sequencing, microsatellites) to investigate the ecology and conservation biology of aquatic invertebrates. Dr. Berg's current research is focused on the partitioning of genetic variation at various spatial scales in populations of freshwater mussels; conservation genetics of desert amphipods; and regional biogeography in the northern Chihuahuan Desert.

David P. Braun

Senior Watersheds Biohydrologist and Director, Agricultural
Watersheds Initiative, Upper Mississippi River Program,
The Nature Conservancy, USA

David P. Braun is Senior Watersheds Biohydrologist with The Nature Conservancy's Upper Mississippi River Project, for which he serves as the Director of its Agricultural Watersheds Initiative. He also serves as a member of the organization-wide Conservation Measures Group and as an advisor to the Conservancy's Alabama River-Mobile Delta project. He has worked for The Nature Conservancy for nearly twelve years, providing guidance to conservation practitioners throughout the U.S. on freshwater ecosystems and biodiversity; the assessment and abatement of threats to freshwater ecosystem integrity; and the monitoring of freshwater ecosystems and the effectiveness of conservation actions. Dr. Braun's education includes an A.B. from Harvard, a

Ph.D. from the University of Michigan (Anthropology), and a subsequent M.S. degree in Hydrology from the University of Arizona. He has numerous publications in anthropology, biohydrology, and conservation impact assessment.

Sharon Brooks

School of Biological Sciences, University of East Anglia, UK

WATER SNAKES, LIVELIHOODS, AND CONSERVATION: TONLE SAP, CAMBODIA

The Tonle Sap freshwater ecosystem is home to eight species of water snakes that are being heavily hunted to provide a source of income for some of the poorest people in Cambodia. Snake hunting has a long history in Cambodia, but in recent years a trade of phenomenal scale has developed in response to a growing demand for a cheap source of protein by the booming crocodile farm industry. We have set up a participatory monitoring program showing that over a seven month season, 3.5 million snakes are landed at the three major trading ports, raising strong concerns over the future for these snake populations.

Our research aims to assess the sustainability of this trade using a livelihoods approach to address the driving force behind the exploitation, rather than simply the consequences of it. Understanding how snake hunting fits into people's highly seasonal patterns of economic activity and their diverse livelihood strategies is an important component of developing appropriate conservation advice to ensure persistence of the snake populations.

Through interviews, discussion groups, and monitoring, we have found that the rate of exploitation varies seasonally according to both the availability of snakes and of alternative resources that drive fluctuations in prices and incentives for targeted hunting. Snake hunting is a low margin economic activity, only pursued when fish catches fall below a certain threshold. Using a livelihoods approach to sustainability analysis thus enables us to identify the decisions of resource users and integrate these into conservation planning.

Sharon Brooks is a Ph.D. student from the University of East Anglia (UEA) in the UK. She has been involved with reptile and amphibian conservation within the herpetology department at the Jersey Zoo, and through working with the Mauritian Wildlife Foundation. Following an M.Sc. in Applied Ecology and Conservation, her focus shifted to incorporate the human component of conservation, working with the Sri Lanka Wildlife Conservation Society on the resolution of human and elephant conflict. Her research now lies at the interface between wildlife conservation and development, focusing on the conservation of exploited snake populations and associated livelihood issues in Cambodia.

Karen Bushaw-Newton

Assistant Professor, Microbial Ecology & Biogeochemistry, American University, USA

ECOLOGICAL IMPACT OF SMALL DAM REMOVAL

The removal of a small dam from a stream ecosystem affects not only the physical but also the biological and chemical aspects of the ecosystem. Understanding how all components interact with each other as well as react to the removal of the dam is key for developing dam removal as an effective tool for stream restoration. In 1999, the Patrick Center for Research and the University of Delaware began an integrative study to determine the ecological responses to the removal of a 2m high dam on lower Manatawny Creek in southeastern Pennsylvania. The Manatawny Creek study employed an integrative monitoring program to assess the physical, chemical, and biological responses to dam removal. Monitoring was carried out prior to and post (2+ years), the two-stage removal in August and November 2000. Comparisons of the results of the Manatawny Creek Removal with other monitored dam removals have highlighted similarities as well as differences on the overall effects to the physical, biological, and chemical components of a stream system. This talk will explore many of the known effects of small dam removal on the ecology of stream systems, highlighting the Manatawny Creek study, and will discuss monitoring considerations when evaluating future dam removals.

Karen Bushaw-Newton is an aquatic ecologist with research interests in the microbial ecology and biogeochemistry of aquatic ecosystems and the restoration of degraded aquatic systems. She received her Ph.D. in Ecology from the University of Georgia; was a NOAA Knauss Policy Fellow, and conducted post-doctoral research at the Patrick Center for Environmental Research within the Academy of Natural Sciences in Philadelphia. Dr. Bushaw-Newton is currently an assistant professor of biology at American University, Washington, D.C.

Leandro Castello

Mamirauá Sustainable Development Institute, Brazil and College of Environmental Science and Forestry, State University of New York, USA

COMMUNITY-BASED MANAGEMENT OF PIRARUCU IN MAMIRAUÁ, AMAZON, BRAZIL

*Conserving the Amazon várzea floodplains in Brazil depends, among other things, on community-based management (CBM) schemes, so increasing the numbers and the effectiveness of CBM is important. In an ecosystem characterized by marginalization of local fishers, poorly developed government institutions, and an open-access natural resource use regime, a model now exists for the CBM of pirarucu (*Arapaima gigas*). Pirarucu is a giant and obligate air-breathing fish that is vulnerable to*

extinction. Every year, local fishers at the Mamirauá Reserve assess the population of pirarucu by counting the fish at the moment of aerial breathing and then use the data to determine fishing quotas for the next year. The Mamirauá Institute mediates negotiations between the fishers and the government and assists in the selling of the catch. The fishers commit to obeying size, season, and quota regulations, and earn exclusive rights over the local pirarucu. Where this model was implemented, fishers saw profits double and pirarucu populations recovered by doubling in numbers every year. Following spontaneous requests from the fishers, the number of communities involved was increased from four to more than 30. By matching and assigning the responsibilities of each stakeholder group with the appropriate levels of capacity and scale, this CBM model conserves the pirarucu and establishes an ecologically benign social structure.

Leandro Castello studies and works with the conservation of the giant and obligate air-breathing fish pirarucu (*Arapaima gigas*) in the Amazon. A member of the Mamirauá Institute, Mr. Castello has helped develop and implement effective strategies for the sustainable use of pirarucu in several localities of Brazil and Guyana. With a Bachelor degree in oceanography and a Master's in public administration and policy, Mr. Castello is now pursuing a Ph.D. in conservation biology in the United States. His Ph.D. study addresses pirarucu migration and population dynamics, fishers' knowledge and integration into management, and the sustainability of the pirarucu fishery as a whole.

Ning Labbish Chao

Universidade Federal do Amazonas, Manaus, AM Brazil and Bio-Amazonia Conservation International, USA

Project Piaba: Evaluating Success in Aquatic Conservation through a Sustainable Ornamental Fishery in the Amazon Basin

*Contrary to the conventional wisdom that the wildlife trade is "evil," Project Piaba was developed to advocate and enhance an existing extractive ornamental fishery to alleviate pressure on environmentally damaging activities and poverty in the Rio Negro basin, Brazil. We have achieved the goals of biological data acquisition and fishery monitoring, and of involving fisher communities and stakeholders. Yet, our work over the past fifteen years has generated several findings of concern: (1) the fishery is almost completely based on a single species, cardinal tetra (*Paracheirodon axelrodi*), which constitutes over 80% of a total annual catch of 40 million and thus is vulnerable; (2) large scale cultivation of Amazon fishes outside the region and introduction of invasive species would endanger the fishery or trade; (3) the paradigm of bottom-up management involving all stakeholders is not often applicable within the local social and cultural framework. The loss of the fishery would be disastrous for the region socio-economically and environmentally. Although significant changes in attitudes toward rainforest and wetland conservation have occurred in the local communities, a strong and persistent local leader with political connections and global views has yet to emerge. Is our slogan "Buy a fish save a tree" too pretentious?*

Born in mainland China, **Ning Labbish Chao** grew up in Taiwan, received graduate training in the United States and Canada, and has focused his career in Brazil over two decades. Studying Amazon fish is his dream come true, and advocating aquatic conservation and the well-being of fisher folk are a romantic choice. Dr. Chao believes in individual initiative and persistence in working from the bottom-up, which is not often "bio-politically" correct. With the multifaceted goals and tasks of Project Piaba, managing crises has become Dr. Chao's daily routine.

Dan L. Danielopol

Senior Scientist, Austrian Academy of Sciences, Institute of Limnology, and Professor of Groundwater Ecology and Invertebrate Zoology at the University of Vienna, Austria

Videography of Subsurface Aquatic Life — A Useful Procedure to Make Environmental Conservation of Subterranean Animals Attractive: The Lobau Wetlands (Austria) Experience

Photography or video of aquatic cave life is a highly appreciated subject for the public, widely distributed by the TV media. It is less frequent to see the life existing in micro-porous (or loosely packed) sediments. Experience with an easy videographical technique for the observation of porous systems and their living interstitial organisms is presented. With a mini-video camera slipping through a lucid piezometre tube, one is able, from the earth's surface, to observe the way groundwater-dwelling animals move through the space between sandy-gravel grains. Additionally, details of microhabitat structures, like biofilms developed by interstitial microorganisms, can also be captured in a dynamic way. Hence, lay people are able to follow the natural life within loosely packed sediments. It is a common belief that the subterranean environment is very constraining due to its low energetic resources and lack of light, and that only a few animals can sustain perennial populations in such environment. The sites we investigated lay within the wetlands of the Danube in an Austrian National Park, closely located to Vienna and colonized by a diverse groundwater fauna with unique or very rarely encountered species. The information acquired by videography is useful to better understand the ecology of those poorly known animals. Videography is also valuable for educational and/or environmental conservation programs. Many people who viewed our video material and received information about species which exclusively live in subterranean waters got, for the first time, the feeling that this environment is worth being protected because of its support to diverse organismic assemblages. It helps therefore to

convey to the public the importance of services and goods provided by groundwater ecological systems. Finally we show how we integrated videography of subterranean organisms within a program dealing with the history and culture of the city of Vienna.

Dan L. Danielopol is Research Assistant at the Institute of Limnology of the Austrian Academy of Sciences and Professor of Groundwater Ecology and Invertebrate Zoology at the University of Vienna. Dr. Danielopol has studied biology at the University of Bucharest, Romania, and received a Ph.D. degree from the University of Vienna, Austria. During the last 25 years he contributed to the development of what is now known as the "New Groundwater Ecology" with studies on groundwater ecosystems. His favorite model was an experimental area, Lobau, in the Danube wetlands closely located to Vienna. His research interests also concentrated on the better documentation of the taxonomic diversity of groundwater crustaceans and the evaluation of their interest for environmental protection. During recent years he has been involved in activities dealing with the environmental protection of groundwater systems at various levels of generality, from the national Austrian one, to the European, and finally to the world wide level.

William Darwall

Head of the IUCN (World Conservation Union) Freshwater Biodiversity Assessment Programme

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William Darwall is Head of the IUCN Freshwater Biodiversity Assessment Programme and is responsible for all aspects of the development and management of this global program. Prior to this time he has gained 13 years experience in biodiversity assessment and conservation of aquatic systems including positions of fisheries research ecologist in Central Africa's Lake Malawi/Nyassa/Niassa (EU), biodiversity survey planner and trainer on the Lake Tanganyika Biodiversity Project (GEF/UNDP), and marine program coordinator (East Africa) for the UK-based Society of Environmental Exploration. Dr. Darwall received his B.Sc. in Zoology from St. Andrews University, Scotland; his M.Sc. in Fish Ecology and Evolutionary Biology from the University of Utah, USA; and his Ph.D. from the University of Hull, UK.

Pierre de Villiers

Environmental Affairs Directorate, Department of Tourism, Environmental and Economic Affairs, Free State Province, South Africa

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A Bottom-Up Approach to Monitoring, Conserving, and Managing in the Orange-Vaal River Basin, South Africa

The South African government in general and more specifically the different Conservation Departments are faced with the challenge of how to conserve biodiversity, but not at the cost of social uplift in the country. The balance between biodiversity conservation and development is a fine one. Neither can be focused on alone. A great deal of funding is rightly being channeled into the Social Departments, but the Conservation Departments are left to develop methods to conserve biodiversity with minimal Governmental funding. The concept of conservancies, protected areas owned privately and managed in accordance with conservation legislation, is not a new one. However, conservancies in the past have often been isolated farms, where the owners simply wish to participate in some form of conservation initiative. The critical issue now is that Conservation Departments must identify sensitive areas, convince the landowners to buy into the conservation ethic, and finally link these conservation areas to form an overall ecosystem or biosphere conservation area.

Members of the Orange Vaal Yellowfish Conservation and Management Association are attempting to do this using the riparian ecosystem as the target ecosystem. Important habitats and their associated sensitive indicator species have been identified. The two endemic Yellowfish species are the identified indicator species in the Orange Vaal River system. Angling for these species has been popularized to such an extent that landowners now conserve the fish and their habitat as a basis upon which a tourism industry can be created. In other words the fields of conservation and development are being managed together to achieve the overall goal of biodiversity conservation and social uplift.

Pierre de Villiers completed a B.Sc. in Biological Sciences at the University of Natal in 1984, and then completed a B.Sc. Hons and an M.Sc.. in Ichthyology and Fisheries Science at Rhodes University in 1991. Mr. de Villiers then started working for the Provincial Conservation Department in 1992. His first post was at the Gariep Dam State Fish Hatchery where he got to know and understand the indigenous fish of the Orange Vaal River system. He then moved on to river conservation in 1996, and now chairs and manages the River Health Programme for the Free State Province and the Orange Vaal Yellowfish Conservation and Management Association. He helped develop and also served on the executive committee of the Yellowfish Conservation Forum of South Africa. His challenge now is to link river ecosystem conservation planning and management to that of the terrestrial systems. This will result in effective overall biodiversity conservation in this region.

Lucy Emerton

Regional Group Head, Asia Ecosystems and Livelihoods Group, IUCN - The World Conservation Union, Sri Lanka

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Counting Ecosystems as Part of Development Infrastructure — Using Economic Valuation to Promote Freshwater Biodiversity Conservation in Africa

From an economic viewpoint, freshwater ecosystems remain some of Africa's most under-valued resources. Wetlands all

over the continent have been modified, converted, over-exploited, and degraded in the interests of other seemingly more "productive" or "profitable" land and resource management options. Yet in all too many cases this has ultimately proved to be economically sub-optimal, both in light of the development goals that have caused the freshwater ecosystem loss and degradation in the first place, and also for the human populations that depend on wetland goods and services.

The paper focuses on three case studies from Africa, describing the methodologies and approaches that can be used to assess and articulate the economic value of freshwater ecosystems, and to use this information to influence development decision-making. The case of the Tana River in Kenya describes how wetland valuation has been used to influence the design of a major hydropower dam so as to assure downstream waterflow and economic benefits. The case of Waza Logone Floodplain in Cameroon describes how floodplain restoration to mitigate the impacts of a large-scale irrigation scheme has acted as an important contributor to regional poverty alleviation strategies. The case of Nakivubo Swamp in Uganda outlines how wetland wise use and management can help to achieve urban development goals.

Lucy Emerton is Regional Group Head of the Asia Ecosystems and Livelihoods Group for IUCN — the World Conservation Union. She has a first degree in anthropology and a post-graduate degree in development and agricultural economics. For the past 15 years Ms. Emerton has been working as an environmental economist in Africa, Asia, and Latin America, including setting up and running IUCN's regional environmental economics programs for Asia and Eastern Africa. Ms. Emerton also acts as IUCN's global coordinator for wetlands and water resource economics activities. In addition to her current position at IUCN, Ms. Emerton has worked as consultant and permanent staff for a wide range of other bilateral, multilateral, UN, and other government and non-government organizations in the field of environmental economics. She has particular expertise in the economic valuation of environmental and natural resources, and in the design of economic incentives and financing mechanisms for biodiversity conservation.

Max Finlayson

Principal Researcher, International Water Management Institute, Sri Lanka

COMMUNITY MONITORING OF WETLANDS AT MULTIPLE SCALES

Changes in the wetlands across the vast area of tropical northern Australia are occurring at a number of scales and caused by multiple pressures operating at different spatial and temporal scales. As examples, invasive species have long been a threat and have greatly changed many wetlands; pollution has been more specific; grazing by cattle and feral buffalo and changes in fire regimes have had both specific and more widespread effects. At the same time, global climate change is a serious threat to all low-lying floodplains. While monitoring has occurred, much of it has not greatly enhanced management responses. The reasons for this are not simply an inadequate supply of funds. Key issues include the non-specific nature of the many pressures and the large scales across which they operate. Much of the monitoring has not been well connected with the interests and needs of local people, or it has had little predictive capacity. These are not new issues. The real innovation lies with the successful engagement of local people/communities to agree with and implement suitable programs. Current efforts are focusing on developing more inclusive collaborative approaches, including identifying the role and responsibility of technical experts and community members, and especially, involving local people in risk assessments and evaluations that determine the monitoring directions. The monitoring may or may not engage local people — the technical complexity and scale need to be considered. The key mechanisms are the basic concepts of consultation and communication built around personal relationships and technical competence coupled with empowerment of the community.

Adjunct Professor **Max Finlayson**, Ph.D., B.Sc. (Hons) has recently relocated from Australia to a principal researcher position with the International Water Management Institute in Colombo, Sri Lanka. Prior to the move, Dr. Finlayson was Director of the Darwin-based Environmental Research Institute of the Supervising Scientist. As a wetland ecologist and advisor on management issues he has been a long-time proponent of inter-disciplinary approaches to problem solving. He has worked extensively nationally and internationally on the inventory, assessment, and monitoring of wetlands in wet tropical, wet-dry tropical, and sub-tropical climatic regimes. He is currently the President of Wetland International's Board of Directors and Chair of the Ramsar Wetland Convention's Scientific and Technical Review Panel. For the past 10 years the issues relating to the inventory, assessment and monitoring of the vulnerability of wetlands to multiple pressures, including climate change, have provided a specific focus. Specific project activity has included assessments of invasive species and the vulnerability of coastal wetlands to climate change. This has variously included local communities and collaboration with other expert groups, and has resulted in the development and implementation of integrated techniques for wetland inventory, assessment and monitoring, including the critical, but often not well executed, components of consultation and communication. Building bridges between technical experts and local communities has been a bigger challenge than expected!

Ellen V. Futter

President, American Museum of Natural History, USA

Ellen V. Futter has been President of the American Museum of Natural History since November 1993. She previously served for 13 years as President of Barnard College, where, at the time of her

inauguration, she was the youngest person to assume the presidency of a major American college. She is a director of a number of organizations and has a strong record of public service, including having served as Chairman of the Federal Reserve Bank of New York. Ms. Futter is also a fellow of the American Academy of Arts and Sciences, and a member of the Council on Foreign Relations. She has been awarded numerous honorary degrees. Ms. Futter graduated Phi Beta Kappa, *magnum cum laude*, from Barnard College in 1971. She earned her J.D. degree from Columbia University Law School in 1974.

Stanley Gregory

Professor, Department of Fisheries and Wildlife, Oregon State University, USA

Alternative Future Analysis in the Willamette River Basin

Landscapes throughout the world are facing increased rates of land conversion, often in the face of increasing human populations. Decisions about resource use frequently are made under intense public pressure and short timeframes. Our research in the Willamette River basin has analyzed trajectories of ecosystem change from 1850 to the present and potential trajectories through 2050. We documented trajectories of change in watershed land cover, channel structure, and riparian plant communities for all 2nd-4th-order tributaries and the 270-km mainstem of the Willamette River. We also mapped current human systems (population density, buildings and roads, public lands, land values, land use) as measures of social opportunities and constraints. We also measured the consequences in future alternatives as described by stakeholders in the Willamette River basin. Scenarios of change from 2000 to 2050 were developed for current policies and practices, development alternatives, and conservation alternatives. Current policies and practices resulted in continued but decreased rates of decline in fish and wildlife communities, but plausible conservation practices resulted in the reversal of such declines. We are developing and will illustrate a multi-agent model of future landscape change based on people's decisions about economic and ecological scarcity on the lands they own or manage.

Stanley Gregory is a Professor in the Department of Fisheries & Wildlife at Oregon State University. He received his B.S. in Zoology from the University of Tennessee in 1971, M.S. and Ph.D. in Fisheries Science from Oregon State University in 1974 and 1980. Dr. Gregory was leader of the Field Station of the National Fisheries Research Laboratory of the U.S. Fish and Wildlife Service from 1977-81. He has been involved in the development of interdisciplinary ecological studies for more than three decades. He has participated in the International Biological Program and the Long-Term Ecological Research Program at the H.J. Andrews Experimental Forest. Dr. Gregory has directed the stream research program informally known as the Stream Team since 1986. This interdisciplinary research program has been recognized for its contributions in teaching and research by the College of Agricultural Sciences, the College of Forestry, and the U.S. Forest Service. His research now includes nutrient dynamics, hyporheic processes, restoration, wood and habitat relationships, fish assemblages in large rivers, riparian management and restoration, and analysis of alternative future scenarios for large river basins.

Olivier Hamerlynck

Former Advisor, IUCN Wetlands and Water Resources Programme

From Thriving Wetland to Saline Desert and Back: Floods for Restoration in Hostile Lands

In the 1960s, the floodplains and delta of the Senegal River were a patchwork of thriving wetland ecosystems supporting a range of livelihoods. Sedentary fishermen and their grass-collecting spouses, desert nomads with camels, and Sahelian nomads with cattle found ample resources after decades of generally adequate natural floods. The drought of the 1970s reduced the Senegal River to a trickle, decimated livestock, sedentarised the nomads, and made natural resource dependent livelihoods precarious. In response, Mali, Senegal, and Mauritania created a river basin authority that planned the sectoral development of irrigation, hydropower, and river transport and built two large dams to achieve ambitious development goals. The environment and traditional livelihoods were low to nonexistent on the agenda, and in the 1980s, after completion of the dams, most flood-dependent ecosystems were in a dire state. In particular, the Mauritanian part of the delta became a saline desert, characterized by rural to shantytown drift. In the 1990s, these trends were reversed and the area was revived through managed flood releases into the Diawling National Park and an artificial estuary. The local tribes, familiar with "traditional" protected area management, were initially hostile to conservation. Gaining their confidence and cooperation in planning, monitoring, and evaluation was slow, difficult, and characterized by numerous setbacks. Helped by the favorable results of the negotiated consensus flood scenario, various user groups increasingly adhered to conservation for sustainable use. However, development expectations not fulfilled, e.g. a drinking water supply, still foster tension between communities and the protected area management authority.

Olivier Hamerlynck studied medicine and practiced as a surgeon in Somalia and Afghanistan during the wars of the 1980s. He then did a Ph.D. on fish and crustaceans of estuarine ecosystems and coastal areas and taught tropical fisheries ecology at the Universities of Ghent and Brussels in Belgium. In 1993, he joined IUCN and spent seven years repairing dam related ecological damage in the Senegal River Delta, initiating the integrated coastal zone management plan, and developing a national wetland

experts network, etc. in Mauritania. After a six-month stint in Mali to support projects in the inner delta of the Niger River, he moved to Tanzania for three years to contribute to the development of the Management Plan for the Lower Rufiji River and its forests, floodplain, and delta. He is now an independent consultant working on wetlands and protected area management in Africa with a strong emphasis on the role of local communities.

Stephen Hamilton

Associate Professor of Zoology, W.K. Kellogg Biological Station and Department of Zoology, Michigan State University, USA

Remote Sensing of Freshwaters to Support Conservation Efforts

Remote sensing is increasingly important in providing a foundation for conservation planning. Advances in technological capabilities as well as data analysis and accessibility promise further gains in the future. A group of remote sensing scientists convened prior to this symposium to take stock of progress and to articulate priorities for future research in freshwater remote sensing to support conservation efforts. New technologies will substantially improve our understanding of freshwater environments, although remote sensing applications for conservation would be optimized with concerted international efforts to link field data collection with remote sensing data analysis. Remote sensing contributes critical information for conservation planning that spans spatial scales from meters to tens of kilometers, as demonstrated with examples from remote regions of South America and elsewhere. Currently available remote sensing data sources include optical sensors, passive microwave emission, synthetic aperture radar, and elevation data from the Shuttle Radar Topography Mission. Spatial data analysis approaches, including hydrological modeling in Geographic Information Systems (GIS) and object-oriented image analysis, are rapidly evolving. The conservation community needs to keep abreast of the growing potential of these data and tools.

Stephen Hamilton is Associate Professor at Kellogg Biological Station, Michigan State University (USA), where he has worked since 1995. He holds a doctoral degree from the University of California at Santa Barbara and a Master's degree from the University of Colorado at Boulder. Dr. Hamilton's principal research interests involve ecosystem ecology and biogeochemistry, with particular attention to aquatic environments and the movement of water through landscapes, and he is especially interested in running waters, wetlands, and floodplains. He has published extensively on South American rivers and floodplains, dealing with a wide variety of research topics, and since 1981 he has spent over six years residing in Venezuela and Brazil in the course of his field research activities. Most recently he has also worked on the hydrology of dryland river systems in Australia, and on remote sensing of floodplains for conservation planning in the Madre de Dios River in Peru. Remote sensing has been an important tool in many of his investigations. Dr. Hamilton also performs research on Michigan lakes, streams, and wetlands.

Ian Harrison

Research Assistant, American Museum of Natural History Department of Ichthyology, and Project Coordinator for the American Museum of Natural History's Center for Biodiversity and Conservation, USA

Ian Harrison joined the American Museum of Natural History as a postdoctoral fellow in 1996 and has conducted scientific research on the taxonomy and biogeography of marine, brackish, and freshwater fishes, studying the systematics of mugilid and gobioid fishes in particular. He is currently contributing to two African ichthyological projects at the Museum: the compilation of distribution data for a forthcoming book on the fresh and brackish water fishes of the Lower Guinea province of west central Africa (co-edited by M.L.J. Stiassny, C. Hopkins and G.G. Teugels); and a geoinformatic project mapping fish diversity and habitat heterogeneity of the Lower Congo Ecoregion. Dr. Harrison contributed to a Center for Biodiversity and Conservation (CBC) project investigating extinctions within the last 500 years. He and Dr. Stiassny are currently reviewing their extinction data for freshwater fishes as part of a study of global patterns of threat to the fauna. Dr. Harrison coordinates the US-based activities of the CBC's Network of Conservation Educators and Practitioners project. He has also helped develop scientific educational resources on the World Wide Web for K-12 educators and has served as an adjunct professor for City University of New York, teaching classes in ichthyology. He is an Assistant Editor for two international journals, the *Journal of Fish Biology* and the *Journal of Afrotropical Zoology* and is an Advisor to the GenBank Taxonomy Database for fish and amphibians. Dr. Harrison has conducted fieldwork in Europe, Central and South America, West and Central Africa, and the Philippines.

Charles P. Hawkins

Director, Western Center for Monitoring and Assessment of Freshwater Ecosystems, Utah State University, USA

Charles Hawkins is Professor of Aquatic Ecology in the Department of Aquatic, Watershed, & Earth Resources and Director of the Western Center for Monitoring and Assessment of Freshwater Ecosystems at Utah State University. Dr. Hawkins has been on the faculty of Utah State University since 1983 following completion of his Ph.D. in Entomology at Oregon State University. He teaches courses in general ecology, stream ecology, water quality, and professionalism in the life sciences. His research focuses on the ecology and conservation of freshwater ecosystems, with special emphasis on the ecology, conservation, management, and restoration of aquatic and riparian ecosystems; sampling designs and statistical methods applicable to ecological research, monitoring, and conservation; predictive modeling of community composition; use of aquatic biota to assess and monitor ecological integrity; cumulative effects of watershed alteration on the physical, chemical, and biotic condition of aquatic and riparian

ecosystems; and the biology and ecology of freshwater invertebrates, amphibians, and fishes. He currently serves on the Ecological Processes and Effects Committee of the Environmental Protection Agency's Science Advisory Board and the Community Condition Indicators Committee for the H. John Heinz III Center for Science, Economics and the Environment.

Zeb Hogan

Aquatic Ecologist, University of Wisconsin, USA

IMPERILED GIANTS OF THE MEKONG

*Southeast Asia's Mekong River supports a vast freshwater fishery. One of the species caught by local fishers is the Mekong giant catfish (*Pangasianodon gigas*), which, according to The Guinness Book of World Records, is the planet's largest freshwater fish — it can measure 3 meters long and weigh 300 kilograms. But fewer and fewer examples of this huge fish have turned up in nets recently, and last year the World Conservation Union added this catfish to its list of critically endangered species. Although the loss of this charismatic fish would be a tragedy in itself, the plight of the Mekong giant catfish also highlights the precarious position of other large, migratory species inhabiting the Mekong River. This presentation describes research to understand the behavior of these fish in hopes of improving the chances for their long-term conservation. Conservation efforts include a direct program of buy-and-release, tagging, genetic analysis, and outreach. The results of the study have important implications for the sustainable development of the basin and the long-term management of migratory species.*

Zeb Hogan is a postdoctoral fellow at the Center for Limnology, University of Wisconsin in Madison and a World Wildlife Fund Conservation Science Fellow. He received his Ph.D. in Ecology from the University of California, Davis in 2004. His research interests include migratory fish ecology, multi-species fisheries management, the population status of giant freshwater fish, endangered species issues, and conservation genetics. Dr. Hogan is also very much involved in environmental education and outreach. Since 1996, he has worked primarily in the lower Mekong River Basin. He has been studying the giant Mekong catfish (*Pangasianodon gigas*) and other large fish of the lower Mekong River, and has served as director of the Mekong Fish Conservation Project (MFCP). In addition to ongoing efforts in the Mekong, Dr, Hogan is working on two new projects: Salmon Conservation in Mongolia through Sustainable Fly-Fishing and Ecology and Conservation of the World's Largest Freshwater Fish. His most recent article, "The Imperiled Giants of the Mekong," was the feature story of the May 2004 issue of *American Scientist*.

Paul D. Johnson and Steven A. Ahlstedt

Director, Tennessee Aquarium Institute; Biologist, U.S. Geological Survey, USA

THE MIGHTY DUCK — USING DAMS TO RESTORE IMPERILED SPECIES

Recent conservation assessments have demonstrated that freshwater mussels (Mollusca: Bivalvia) are the most critically imperiled animals in North America. Having specific habitat requirements, most mussels require clean, flowing waters and stable river channels to thrive. Within the last 80 years, dam construction, dredging, river navigation projects, and toxic point-source releases destroyed the best populations in the most productive large river habitats. This widespread habitat destruction drove some 36 species to extinction and rendered more than a third of remaining species critically imperiled. Habitat destruction from dams is not restricted to pools, but also extends into the free flowing tailwaters below the dams. Specifically, low dissolved oxygen, depressed water temperatures, and channel destabilization are common problems that can extend for tens of kilometers below reservoir pools. However, these tailwater effects can be drastically mitigated to improve conditions for riverine species. Such is the case with Normandy Dam on the Duck River, a flood-control, water supply reservoir operated by the Tennessee Valley Authority (TVA) that controls some 95% of the river's length. In 1991, TVA completed major modifications improving dissolved oxygen levels and seasonal discharge cycles during critical spring and summer mussel and fish spawning periods. Mussel abundance and species richness per site increased drastically from previous surveys in years before discharge and dissolved oxygen restoration. With 53 extant species, the Duck River likely has the highest diversity of freshwater mussels for any river globally. Dam tailwater restoration through dissolved oxygen mitigation, improved temperature conditions, and stabilization of discharges can provide suitable habitat rapidly, whereas traditional watershed restoration methods may take decades to achieve. We advocate an emphasis on tail-water restoration by conservation organizations as a rapid habitat recovery technique. Efforts to cultivate freshwater mollusks are under development and great strides have been made in the last decade. What is now required to save additional species are large, productive river habitat suitable to attempt reintroduction and recovery efforts.

A native of Kentucky, **Paul Johnson** earned his Bachelor's and Master's in Aquatic Biology from the University of Louisville. He earned his Doctorate in Zoology from Louisiana State University in 1995, under the direction of Ken Brown. A two-year Postdoctoral Program was completed at the Center for Comparative Molluscan Physiology at the University of Texas at Arlington with Bob McMahon. Dr. Johnson has worked for the Tennessee Aquarium Research Institute (TNARI) since 1997, and has been its Director since 2003. The mission of TNARI is to

develop and implement recovery programs with native imperiled mollusks, fishes, and turtles. Dr. Johnson's work focuses on freshwater mollusk propagation and recovery efforts with Mobile and Tennessee River basin species.

Wolfgang J. Junk

Scientist, Max Planck Institute for Limnology, Working Group Tropical Ecology, Germany

Pantanal: Driving Forces and Terrestrial-Freshwater Interactions

Protection of wetland biodiversity has been addressed mostly in terms of wetland species and/or specific wetland habitats. However, in wetlands with strongly oscillating water levels (floodplains), periodic drought in the aquatic-terrestrial transition zone is of fundamental importance for biogeochemical cycles, productivity, and species diversity as shown by the Flood Pulse Concept (FPC, Junk et al. 1989, Junk & Wantzen 2004, Junk 2005). This is demonstrated in the Pantanal, a large wetland of about 160,000 km2 in the center of South America. Large parts of the area are periodically flooded by the Paraguay River and its tributaries, and by local rains. This monomodal, rather predictable flood pulse is the major driving force of the system. It influences the occurrence, population size, and distribution of plants and animals and determines their life history traits. Topographical changes of a few meters in height, resulting from paleo and recent river activity, lead to considerable spatial differences in flood height and duration and result in high habitat and species diversity, including aquatic, palustric, and terrestrial species. Fire becomes an additional stress factor during the pronounced dry period. Reactions of flora and fauna to the annual and multiannual changing water levels can now be predicted by the FPC, which can be applied for all wetlands with strongly fluctuating water levels. The FPC is becoming the scientific basis for sustainable management of floodplains, including the protection of biodiversity.

Wolfgang J. Junk began his scientific career in 1967 in Manaus, Amazonas, Brazil, where he conducted the fieldwork for his doctoral thesis at the National Amazon Research Institute (INPA) with a scholarship from the Max Planck Institute for Limnology, Plön, Germany. After a nine-month post-doc at Bung Borapet in Thailand, he returned in 1973 to INPA, and assumed in 1974 the position of head of Department of Fish and Fisheries. For four years he developed the department and established a post-graduate course. In 1980 he assumed the position as head of the Working Group of Tropical Ecology at the Max Planck Institute. Since then, his team (together with Brazilian partners) has conducted research on ecology and sustainable management of the Amazon River floodplain. In 1990, the collaboration was extended to the Federal University of Cuiabá to study the Pantanal of Mato Grosso. Professor Junk has published about 200 articles and edited or co-edited several books about floodplain ecology and management. He is a corresponding member of the Brazilian Academy of Sciences and was honored with several distinctions, including the highest scientific award of Brazil (Gran Cruz) and the International Fellow Award of the Society of Wetland Scientists.

Richard Kingsford

Professor of Environmental Science, School of Biological, Earth and Environmental Science, University of New South Wales, Australia

Freshwater Ecosystems and Mobile Species in Australia: Is Conservation Possible When Current Models for River Conservation Are Poor?

Australia is a dry continent with about 70% of its land mass receiving <500 mm year-1. Rainfall events are highly variable, producing flooding on inland rivers that inundate large floodplains and wetlands, providing habitat for many biota, including waterbirds. Waterbirds capitalize on uncertainty in the availability of wetland areas through highly nomadic movements, following flood events and breeding when food resources are high. Many rivers and wetlands in the southeast no longer flood to the same extent and frequency as they did naturally because of extractions of water for irrigated agriculture. Water is diverted upstream of river systems that supplied some of the more biodiverse wetlands on the continent. Traditional forms of protection through protected areas and Ramsar nominations have failed to protect these wetland areas. Rehabilitation costs are increasing as wetland areas degrade. The Australian Governments are spending $Aus 500 million to rehabilitate the River Murray in southeastern Australia. At the same time, some of Australia's less developed rivers (in the tropics and central Australia) are becoming the new frontiers for river development. There is a need to establish a more strategic framework for river and wetland conservation in Australia that recognizes the many mechanisms that can protect significant areas and different spatial scales. This framework would need to identify rivers, estuaries, and wetlands of high conservation value across Australia. Once identified, two main options exist for protection: 1) whole river basin protection or 2) protection of dependent ecosystems at the catchment scale. Two new examples of multilateral (Lake Eyre Basin Agreement) or bilateral agreements (Paroo River Agreement) between governments exist that protect flows in whole river systems. These were developed by governments with pressure primarily from river communities. Such a model could be the basis for an Australian Heritage Rivers system to protect whole river basins, like that in Canada. For adequate protection of dependent freshwater ecosystems, a much wider focus is required that includes protected areas (including aquatic reserves) acquisition and management, environmental flows, natural resource management and incentives. Together or in part, they can effect long-term protection of

dependent ecosystems (river segments, estuaries, wetlands) — but this will depend on political and community will.

Professor **Richard Kingsford** is in the School of Biological, Earth and Environmental Science at the University of New South Wales in Sydney. He completed a Ph.D. on waterbirds at the University of Sydney in 1986 and has focused his research over the last 20 years on the waterbirds, wetlands, and rivers of arid Australia, which cover about 70 percent of the continent. He has particularly been interested in flow patterns of some of the great desert rivers in Australia such as Cooper Creek. Australia's inland wetlands support spectacular waterbird populations, which feed on fish, aquatic plants, and invertebrates. Aerial surveys of waterbirds, mapping of wetlands, and development of software for delivering knowledge about catchments are other areas of his work. His research has demonstrated the ecological values of many rivers and impacts of water resource in arid Australia. More recently he has spent time actively working with river communities on catchment committees and agreements for conserving river flows. He is currently editing a book on the desert rivers of the world.

Roland A. Knapp

Research Biologist, Sierra Nevada Aquatic Research Laboratory, University of California, USA

Turning Back the Clock: Restoring Lake Ecosystems by Eradicating Introduced Fish

The majority of mountain lakes worldwide were naturally without fish, and as a consequence harbored a unique vertebrate and invertebrate fauna. During the past century, intentional fish introductions have profoundly altered these sensitive ecosystems by extirpating native fauna and rearranging ecosystem processes. The severity of these impacts is now widely recognized, and has prompted increasing interest in restoring some mountain lakes to their natural fishless condition. It remains unclear, however, whether fish removal alone is sufficient to allow ecosystem recovery. We removed non-native trout populations from a series of alpine lakes in California's Sierra Nevada, and quantified subsequent faunal recovery. Following fish removal, the faunal composition of the study lakes diverged from that characteristic of fish-containing lakes and after seven years, had converged on that characteristic of naturally fishless lakes. In addition, the total invertebrate biomass in the fish removal lakes increased more than an order of magnitude. The spectacular recovery of the aquatic ecosystem has also had surprising consequences for the surrounding terrestrial ecosystem, particularly for alpine-nesting birds. These results suggest that the impacts of fish introductions are more far-reaching than previously believed, but also that these impacts can in some cases be reversed.

Roland Knapp received his professional introduction to aquatic ecosystems as an undergraduate research technician studying the effects of air pollution on lakes and streams in California's Sequoia National Park. Since receiving his Ph.D. from the University of California, Santa Barbara in 1992, he has served as a research biologist at the University of California Sierra Nevada Aquatic Research Laboratory. In 1995, Dr. Knapp began an intensive study of the effects of non-native trout on mountain lake ecosystems, a study that eventually involved faunal surveys at 8000 water bodies in Sequoia, Kings Canyon, and Yosemite National Parks. Since 1996, he has also been conducting a long-term whole-lake experiment designed to quantify the recovery dynamics of lake ecosystems following the removal of non-native trout populations.

Bernhard Lehner

Freshwater GIS Specialist, Conservation Science Program, World Wildlife Fund-USA

Hydrology for the World: New Global Data, Tools, and Applications

The bottleneck in conducting hydrological analyses is often the lack of available data and information, particularly in remote areas. For many hydrological applications, from watershed delineation to advanced modeling, the most essential and versatile data set is a digital elevation map. With Geographic Information Systems (GIS), many other data sets can be derived from this core product, including watershed boundaries, river networks, flow distances and connections, slopes, or even erosion and soil moisture indices. In turn, these products are important for understanding how hydrology and biology interact to support freshwater species and habitats, and how threats are propagated and must be addressed. Recently, a new elevation data set (SRTM - Shuttle Radar Topography Mission) became available, which covers nearly the entire global land surface at 90 m resolution. Scientists at World Wildlife Fund (WWF) are currently post-processing this data so that the above-mentioned products can be derived. At the same time, relatively easy to use GIS tools are developed for the handling of the hydrological data in different analyses. These include hydrographic tools (for basic watershed analyses and classifications), hydrologic tools (to incorporate results of existing global or regional modeling systems), and decision support tools (to help identify priority areas or to better understand complex processes). Data and tools have already been successfully tested for a remote portion of the southwest Amazon basin and for the Guyana Shield.

Bernhard Lehner works for the Conservation Science Program at World Wildlife Fund US. He provides expertise on hydrology and climate change, in addition to GIS support for both the US freshwater conservation team and WWF's international ecoregion programs. Current projects include the integration of hydrology into freshwater biodiversity studies (hydrologic alteration, threat analyses) and the development of global hydrologic data sets and GIS tools. Before joining WWF-US, Dr. Lehner worked at the University of Kassel, Germany, where his main responsibilities

included a model-based assessment of climate change effects on continental water resources and hydrologic regimes. Dr. Lehner has received his Ph.D. in hydrology from the University of Frankfurt, Germany.

Patricia Marconi and Sandra Caziani

Fundación YUCHAN, Argentina; Facultad de Ciencias Naturales, Universidad Nacional de Salta-CONICET, Argentina

Conserving Wetland Network across Borders in the Altiplano

*The "altiplano" of the Central Andes extends through Argentina, Bolivia, Chile, and Perú, between 3,500 and 4,500 m above sea level. Numerous endorrheic basins form lakes and salt pans (called "salares"), producing patches of aquatic habitat within a desert matrix. At a landscape scale, the typically dissimilar wetlands form complex habitats that are seasonally and spatially diverse. Hypersaline shallow lakes have abundant diatoms but no macrophytes, attracting large numbers of Andean (*Phoenicoparrus andinus*) and James flamingos (*P. jamesi*). The deepest lakes are rich in zooplankton and macrophytes, with higher waterbird diversity. Giant and horned coots, silvery grebe (*Podiceps occipitalis*), crested duck (*Lophonetta specularioides*), and Chilean flamingo (*Phoenicopterus chilensis*) are characteristic of deep lakes.*

High Andes wetlands, their biodiversity, and the environmental goods and services they bring to local people are threatened by mining expansion, underground water pumping, geothermal energy production, gas pipelines and power lines, unregulated tourism, overgrazing, the gathering of firewood, and egg collection. The complementary use of these environments by native fauna and local people suggests that long-term conservation goals would be best achieved by considering these lakes from a regional landscape perspective, and thus proposing its protection and integrated management through cooperative action of the four countries sharing the Altiplano.

To address altiplano integrated management, in December 1996 the Grupo para la Conservación de Flamencos Altoandinos *(High-Andean Flamingos Conservation Group) (GCFA) was created with the participation of scientists and natural resource managers of the four countries which share the species, Argentina, Bolivia, Chile, and Perú. To date, main GCFA achievements at the regional scale include establishing common criteria for wetlands baseline studies and monitoring and prioritizing key sites.*

Sandra Caziani is a biologist, professor at Salta National University, and researcher in CONICET (National Council of Scientific Research in Science and Technology). She has a Doctoral degree from Universidad de Buenos Aires and is responsible for the Research and Monitoring Program in the High Andes Flamingo Conservation Group. Since 1993, she has worked in community ecology and biological conservation in the High Andes. Since 1994, Dr. Caziani, together with Dr. Patricia Marconi, has been in charge of several projects supported by Ramsar Convention, Migratory Species Convention, and Wildlife Conservation Society, working in collaboration with colleagues from Chile, Bolivia, and Perú. Her latest work is related to habitat analyses of waterbirds in the High Andes, and the regional patterns of movements (using satellite tracking) of the rarest flamingo species in the world, the Andean Flamingo.

Patricia Marconi is a conservation biologist, President of Fundación YUCHAN (an NGO devoted to conservation and sustainable use of Southamerican Yungas, Chaco and Andes). She has a doctoral degree from Universidad de Buenos Aires and she is in charge of the Conservation and Management Program of the High Andes Flamingos Conservation Group. She has been working as a conservation biologist in protected areas in the Andes since 1993. Her most relevant achievements during the last ten years have been related to proposal, creation, establishment and/or effective management of protected areas in the Andes, working together with Dr. Sandra Caziani in the reserve design and planning of most of them.

Michael J. Novacek

Senior Vice President and Provost of Science and Curator of Paleontology, American Museum of Natural History, USA

Michael Novacek has served since 1982 as a curator at the American Museum of Natural History where he is currently Senior Vice President and Provost of Science and Curator of Paleontology. Awarded a doctoral degree (with honors for outstanding graduate research) at the University of California, Berkeley (1978), his studies concern patterns of evolution and relationships among extinct and extant organisms. His interests have ranged from paleontological evidence to new data on DNA sequences. He has led paleontological expeditions to Baja California, the Andes Mountains of Chile, the Yemen Arab Republic, and Gobi Desert of Mongolia in search of fossil dinosaurs and mammals. Dr. Novacek is the author of more than 150 titles, including articles in the international scientific journals *Science* and *Nature*. Since 1982 he has published on the broader evolution of mammals, culminating in a major review of molecular and morphological evidence, featured as a cover article in *Nature* (March 1992). He has co-edited books on *Extinction and Phylogeny* (1992), *Mammal Phylogeny* (1993), and edited *The Biodiversity Crisis, Losing What Counts* (2001). He is the author of a popular book on the Gobi expeditions, *Dinosaurs of the Flaming Cliffs* (1996) and on his experiences as a fledgling paleontologist and eventually an expedition leader, *Time Traveler* (2002) (each recognized as a *New York Times Notable Book of the Year*). As Provost and Senior Vice President at the American Museum of Natural History, Dr. Novacek serves as both the leader and spokesperson for the Museum's scientific mission. He oversees a staff of 200 scientists, graduate and postgraduate fellows, and technicians who have responsibility for one of the world's largest natural history

and cultural collections (32 million specimens and artifacts). In addition to his duties as Provost, Dr. Novacek has served as President of the Society of Systematic Biologists, and the Bioadvisory Committee for the National Science Foundation. Dr. Novacek is a fellow of the American Association for the Advancement of Science and the American Academy of Arts and Sciences, and received an Honorary Doctorate from Long Island University in 1996.

Mamie Parker

Assistant Director for Fisheries and Habitat Conservation, U.S. Fish and Wildlife Service, USA

The Fish and Wildlife Service and Freshwater Biodiversity: A Focus on Partnerships and an Eye on the Future

Freshwater biodiversity conservation is a central component of the Fish and Wildlife Service's mission, one the agency has proudly advanced for over a century. To maximize conservation successes, we must take a step back, focus on the landscape, work with many different partners, and employ a wide array of tools. Fortunately, many of these tools have a track record of results. A recent agreement on the Penobscot River in Maine, for example, will remove a couple of dams and provide fish passage around another, ultimately helping restore Atlantic salmon to historic spawning grounds – while at the same time maintaining an important source of hydropower. In addition, our partnership programs with private landowners are helping restore important instream, wetland, and riparian habitats, empowering citizens to play a leadership conservation role in their communities. Although some successes are notable, we clearly understand many pressures rising on the horizon will require innovative approaches and strategic investments. To this end, we are leading an initiative focused on fish habitat conservation. We are also compiling baseline information for aquatic populations and sharing it widely, which will help people direct limited resources to the highest priorities. In addition, we are partnering with the U.S. Geological Survey and highlighting four issues that will become even more critical in the years ahead: invasive species, water resources, climate change, and biotechnology. Our goal is to prepare today to effectively address the challenges of tomorrow.

Mamie Parker is the Assistant Director for Fisheries and Habitat Conservation in the U.S. Fish and Wildlife Service, overseeing 750 employees at 70 National Fish Hatcheries, one Historic National Fish Hatchery, seven Fish Technology Centers, nine Fish Health Centers, 64 Fishery Resource Offices and one Genetics Laboratory. She is also responsible for Federal projects review activities oversight, and for more than 70 Ecological Services offices in all 50 states. Dr. Parker began her Service career in 1978 at the Fish Health Laboratory at the Genoa National Fish hatchery in Wisconsin. She spent the next fifteen years in the Great Lakes region both working in the Fisheries program and the Ecological Services program. From there, she went to Atlanta where she served as the Deputy Geographic Assistant Regional Director for the Southeast Region, and as Assistant Regional Director-Fisheries. From Atlanta, Dr. Parker moved to the Director's Office in Washington, where she served as Special Assistant to the Deputy Director and the Director, providing advice, analyses and recommendations on issues affecting Service staff, national policies and the Service's ecosystem approach.

In September, 1999, Dr. Parker was appointed the Service's Deputy Regional Director and Regional Director of the 13 Northeast States, headquarters in Hadley, Massachusetts. She subsequently moved from Hadley to Washington to serve in her current position as the Assistant Director for Fisheries and Habitat Conservation, where she continues to work with partners to move the Fisheries and Habitat Conservation program through its strategic planning process, contributing to healthy fish, healthy habitat, healthy people, and a healthy economy. Dr. Parker earned a B.S. in Biology and Chemistry from the University of Arkansas in 1980, an M.S. in Fishery Biology from the University of Wisconsin at Green Bay in 1981, and earned her Ph.D. in Ecology with emphasis on Limnology (study of lakes) from the University of Wisconsin at Madison in 1986.

Rohan Pethiyagoda

Founder, Wildlife Heritage Trust of Sri Lanka

Conservation of the Freshwater Biodiversity of Sri Lanka

Sri Lanka has experienced the recent extinction of two species of freshwater fishes, 22 amphibians and ~ 130 angiosperms. Its rainforests have declined from 16,000 km² in 1850, to ~ 750 km² at present. The island has the highest human population density of all the global biodiversity hotspots. Habitat loss and degradation, along with invasive alien species, are considered the leading threats to biodiversity. A variety of conservation strategies have been tested, including community-level projects to conserve "point endemic" fishes; community forestry projects to protect natural forest boundaries; in *and* ex situ *conservation projects for medicinal plants; habitat restoration projects for degraded montane lands; insurance schemes for crop damage by elephants; an* ex situ *"orphanage" elephant conservation project; and integrated conservation and development projects to promote sustainable practices among communities living in and near forests. Most conservation projects in Sri Lanka have been implemented by government or community-based organizations, with non-government organizations (NGOs) restricting themselves largely to advocacy. Conservation initiatives have been only partially successful in Sri Lanka given the inability of policy makers to*

reconcile two powerful and opposing paradigms: scientific conservation and sustainable use versus absolute protection, with the trend of extinctions expected to accelerate as a result.

Rohan Pethiyagoda is the founder and managing trustee of the Wildlife Heritage Trust of Sri Lanka, a non-profit organization dedicated to the scientific exploration and documentation of Sri Lanka's biodiversity. Mr. Pethiyagoda, a biomedical engineer by training, received a B.Sc. from the University of London, and an M.Phil. from Sussex University. In 1988, he shifted his career focus to biodiversity research and exploration, conducting the first surveys of Sri Lanka's amphibians, freshwater fishes, and crabs, between 1988 and 1998. In 1990, he established the Wildlife Heritage Trust, which operates almost entirely on revenue from its book and magazine-publishing activity, and is Sri Lanka's largest publisher of biodiversity-related books and periodicals. Mr. Pethiyagoda has authored or co-authored more than 60 papers and four books, including *Freshwater Fishes of Sri Lanka*. He is also an Adviser to Sri Lanka's Ministry of Environment and Deputy Chair of IUCN Species Survival Commission.

Edward T. Rankin

Senior Research Associate, Center for Applied Bioassessment and Biocriteria and Institute for Local Government Administration and Rural Development, Ohio University, USA

THE U.S. CLEAN WATER ACT: INNOVATIVE NATIONAL LEGISLATION GUIDING LOCAL AND REGIONAL FRESHWATER BIODIVERSITY CONSERVATION

The Clean Water Act directs states to set aquatic life goals or "uses" for their surface waters and to derive criteria to protect these uses to restore "chemical, physical, and biological *integrity." Traditionally, states relied on chemistry-based criteria to manage and assess their waters. Direct measures of aquatic life goals by monitoring biological communities were less common and not well integrated into water quality standards programs in states. In the late 1980s several states, particularly Maine and Ohio, derived "biocriteria" for their water quality standards that were direct measures of aquatic communities designed to protect aquatic life uses. Here I provide examples of how these states have used biocriteria to demonstrate the success of point source abatements and to identify the current stressors (e.g., habitat degradation, siltation and sedimentation, loss of natural flow regimes and nutrient enrichment) that now limit biological integrity. I will also illustrate how long-term monitoring data from these efforts has been used to examine watershed scale influences of stressors such as habitat, on losses of biodiversity in these watersheds. These data sets are proving useful for quantifying cumulative impacts at watershed scales and are identifying limits to populations of sensitive fish and invertebrate taxa related to anthropogenic disturbances such as habitat loss. Lines drawn along observed biodiversity thresholds can be considered "extirpation" curves and have strong implications for restoration efforts at local and watershed scales.*

Edward T. Rankin is Senior Research Associate, Center for Applied Bioassessment and Biocriteria and Institute for Local Government Administration and Rural Development, Ohio University, Athens, Ohio. He has some 20 years experience as a fish ecologist for Ohio Environmental Protection Agency. His professional interests include the effects of multiple stressors on aquatic life in streams and watersheds; development and application of stream habitat assessment methodologies; development and application of biological criteria, development of biocriteria-based chemical criteria for aquatic life (e.g., nutrients, sediment, metals, etc), developing processes to improve the accuracy and efficacy of total maximum daily loads (TMDLs) for nutrients and sediments in watershed restoration projects.

Carmen Revenga

Senior Freshwater Scientist, Habitat Assessment Team, Global Priorities Group, The Nature Conservancy (TNC), USA

Carmen Revenga is a senior freshwater scientist at The Nature Conservancy's Global Priorities Group. Currently, she is leading TNC's effort to assess the biological distinctiveness, condition, and threats to freshwater ecosystems around the world. Ms. Revenga started her current position at TNC in October 2004. Prior to that she was based at The World Resources Institute in Washington, D.C., where she led indicator development and policy work on freshwater resources and marine fisheries. She is lead author of *Status and Trends of Biodiversity of Inland Waters* (CBD 2003), *Pilot Analysis of Global Ecosystems: Freshwater Systems* (WRI 2000), and *Watersheds of the World* (WRI et al. 2003; WRI and WorldWatch Institute 1998). She has also co-authored *Fishing for Answers: Making sense of the global fish crisis* (WRI 2004). For the past five years, Ms. Revenga has been actively involved in the Millennium Ecosystem Assessment as the Coordinating Lead Author for the Fresh Water Chapter of the Condition's Working Group, as well as contributing to the Inland Waters and the Biodiversity Condition Working Group Chapters. She received her M.S. in Sustainable Development and Conservation Biology from the University of Maryland and did her undergraduate work in Zoology at the Universidad Complutense in Madrid, Spain.

Brian Richter

Director, Freshwater Initiative, The Nature Conservancy, USA

Brian Richter has been involved in river science and conservation for more than 20 years. He is the Director of The Nature Conservancy's Sustainable Waters Program, an initiative that is supporting conservation projects across the Americas, Asia, and the Pacific Region. Richter's work is focused on the global

challenges of meeting human needs for water while keeping river and lake ecosystems healthy. He works with public agencies, academic institutions, and other private organizations, and leads a staff that includes hydrologists, aquatic ecologists, policy specialists, educators, and communicators. Richter has developed numerous scientific tools and methods to support river restoration efforts, including the Indicators of Hydrologic Alteration software that is being used by water managers and ecologists worldwide. He has published numerous scientific papers on the importance of ecologically sustainable water management in international science journals, and co-authored a book with Sandra Postel entitled *Rivers for Life: Managing Water for People and Nature* (Island Press, 2003).

Paul Skelton

Managing Director, South African Institute for Aquatic Biodiversity, South Africa

Bridging Troubled Waters — Taxonomic Science in the Service of Freshwater Fish Conservation in South Africa

Conservation is essentially a process of human intervention to safeguard natural systems and is inextricably linked to prevailing socio-economic and political circumstances in any region. Indigenous scientific services are generally scarce in developing countries. In South Africa, a mixed (i.e. developing) economy, nature conservation agencies were established only in the 1950s, long after the emergence of major threats to freshwater fishes such as the introduction of alien predators. The science of conservation biology evolved over the latter half of the 20th century, so that the role of taxonomists as knowledge-agents for biodiversity has necessarily changed as the ranks of specialist conservation biologists grew. In this presentation the role of taxonomic science in the conservation of freshwater fishes in South Africa is considered against a context of socio-economic and political revolution. The issues are traced through the history of selected examples of seriously threatened species and the major threats affecting the survival of the communities. Much recent research involves the dialogue and active interaction and collaboration between conservation agencies, academic researchers including taxonomists/systematists, private sector consultants, and even private-sector sportfishing interests. Several innovative partnerships provide possible ways forward for the developed, as much as the developing, world. Times of change present challenges and opportunities for innovation not generally available in times of (paradigm) stability.

Paul Skelton is the Managing Director of the South African Institute for Aquatic Biodiversity (SAIAB, formerly the JLB Smith Institute of Ichthyology). From 1972 till 1983 he served as Curator of Fishes at the Albany Museum in Grahamstown, and from 1983 till 1995 as Curator of Freshwater Fishes at the JLB Smith Institute of Ichthyology. His research focused on the taxonomy, biogeography, and conservation of southern African freshwater fishes. He is the author of the *South African Red Data Book – Fishes* (1987) and the book *A Complete Guide to the Freshwater Fishes of Southern Africa*. His recent major projects include the conservation of the Maloti minnow in Lesotho and the development of a database and atlas of southern African freshwater fishes. The latest project (starting 2005) involves SAIAB in a partnership with IUCN-SSC and Wetlands International to provide a Pan-African assessment of freshwater biodiversity in order to facilitate the planning process in African freshwaters. Dr. Skelton has a B.Sc. in Zoology and Entomology from Rhodes University, a B.Sc. with Honours in Zoology, and a Ph.D. in Ichthyology from Rhodes University in 1980; thesis — Systematics and biogeography of the redfin Barbus species (Pisces: Cyprinidae) from southern Africa.

Boris Sket

Professor of Zoology and Speleobiology, University of Ljubljana, Slovenia

Subterranean Animals in Slovenia: Protecting Habitats, Not Specimens

Slovenia is a country rich in cave and interstitial groundwater habitats, and early in 1920 a Slovenian Memorandum suggested protection of karst caves in general. Recent censuses have shown that approximately 8% of European aquatic fauna are highly endemic troglobionts; Slovenia appeared to be comparatively the richest in the world. Molecular analyses even show a certain degree of cryptic diversity within a cave.

In practice, formal protection of troglobiotic species mainly "protects" them from scientific research, the main support of meaningful protection (with limits on collection, which rarely endangers a species). Nevertheless, such protection acts are still common throughout the world, avoiding protection of the habitat. The threats to the groundwater fauna are largely from the surface: pollution, pesticides and fertilizers, urbanization, and hydrotechnical works. We have been able to show that organic inputs allow alien (surface) species to outcompete troglobionts underground.

In 2004 we succeeded in bringing habitat protection into Slovenian legislation (covering nearly all subterranean environment), and only some commercially interesting collector's items are now protected. Some European Union (EU) directives or international actions will likely contribute to conservation success although this has not yet been borne out. The Natura 2000 puts over 30% of Slovenian territory under certain protection regimes, and a big part of this is in karst or along riverbeds (i.e. with cave or interstitial waters). We have not yet succeeded in protecting any

faunistically important cave as a Ramsar subterranean wetland, but the process has begun. Discouragingly, however, the EU Water Directive totally ignores the existence of biota in groundwaters.

Boris Sket is Professor of zoology and speleobiology at the Biology Department, Biotechnical Faculty, University of Ljubljana. He has been heading the research group for zoological and speleobiological investigations. He did some research in ecology of freshwater habitats, including of cave and interstitial waters; taxonomically, he is interested mainly in leeches and some crustacean groups. His main interest is in evolution and historical biogeography of biota in karst areas. The main geographical area of his research is the rich karst area of Dinarides in southern Europe, but he also studied some tropical karst areas. Dr. Sket is the member of editing boards of some international journals and the president of the International Society for Subterranean Biology. He served as the Dean of the Biotechnical Faculty (1983-1985) and as the Rector (President) of the University of Ljubljana (1989-1991). He received some awards, including the state award "The Zois Prize for Outstanding Scientific Achievement" in 2003. Dr. Sket received a degree in biology and a Ph.D. (1961) from the University of Ljubljana, Faculty of Sciences.

Eleanor J. Sterling

Director, Center for Biodiversity and Conservation, American Museum of Natural History, USA

As Director of the Museum's Center for Biodiversity and Conservation (CBC), **Eleanor Sterling** oversees strategic planning and project development, leads fundraising efforts, and manages a multidisciplinary staff of over 25. In her capacity as a conservation biologist, Dr. Sterling also conducts fieldwork, studying the distribution patterns of biodiversity in tropical regions of the world and translating this information into recommendations for conservation managers, decision-makers, and educators. Dr. Sterling has extensive expertise developing environmental education programs and professional development workshops, having trained teachers, students, and U.S. Peace Corps volunteers in a variety of subjects related to biodiversity conservation.

Dr. Sterling has more than 20 years of field research experience in Africa, Asia, and Latin America, where she conducted surveys and censuses, as well as behavioral, ecological, and genetic studies of primates, whales, and other mammals. She is considered a world authority on the aye-aye, a nocturnal lemur found only in Madagascar. For the last eight years, Dr. Sterling has been an adjunct professor at Columbia University, where she now serves as the Director of Graduate Studies for the Department of Ecology, Evolution, and Environmental Biology. Dr. Sterling sits on the Board of Governors of the Society for Conservation Biology, and is both a Board member and Management Committee member of the Center for Environmental Research and Conservation (CERC). Dr. Sterling received her B.A. in psychobiology from Yale College in 1983 and her Ph.D. in anthropology and forestry and environmental studies from Yale University in 1993. She joined the Museum in 1996 as the CBC's Program Director and was named Director of the Center in 2000.

Melanie L.J. Stiassny

Axelrod Research Curator, Department of Ichthyology, American Museum of Natural History and Adjunct Professor at Columbia University, USA

Innovations Around the World: What Do We Need, and Why?

Freshwater is a limited resource that is full of life. It covers only 0.8% of the Earth's surface and represents only 0.01% of the world's water, yet recent estimates suggest that it directly supports upwards of one third of the planet's vertebrates and as much as 8% of all known species. Freshwater is also essential for human health, food production, energy generation, and transportation, and is the focal point of many cultures and religions. Yet the growing water requirements of increasing human populations have changed the hydrology of rivers and lakes around the world, and caused declines in freshwater biodiversity that equal those of the most affected of terrestrial ecosystems. There is an urgent need to address the many environmental problems that impact freshwater systems in the 21st century. One of the first steps in this process is accurate documentation of the species diversity in freshwater ecosystems. For many regions this information is simply not available, either due to lack of taxonomic information about the species present, or because of the practical difficulties in surveying freshwater systems. Conservation planning and management of freshwater resources is further complicated because of the landscape position of rivers and wetlands; the environmental health of lakes and rivers are intimately tied with the terrestrial landscapes around them. Similarly, rivers cut across landscapes and political boundaries, such that management of any part of the drainage may require control of upstream and downstream drainage networks and neighboring terrestrial ecosystems. New "landscape-based" approaches to understanding the geomorphology, hydrology, and ecology of freshwater systems can promote more effective, holistic conservation programs. While there is a need to think broadly in understanding freshwater ecosystems and in implementing conservation programs, there is also an imperative to think locally in terms of the communities affected by programs for water development, management, and use. Twentieth century water "hard path" polices have focused on massive infrastructures of dams, pipes, and channelized systems, with the intention of serving distant communities over large areas often remote from the water sources exploited. Sadly, all too often these programs have failed to achieve their stated goals while damaging local ecosystems and

economies and hence the human communities at the sites of those dams, pipelines, or otherwise manipulated freshwater ecosystems. New "soft path" approaches that account for local community and stakeholder interests, place greater value on maintaining environmental health, and promote more sustainable resource use are needed. Indeed, many new programs for freshwater conservation, restoration, and management have been successful precisely because they rest on a bottom-up approach, involving conservationists, local community groups, businesses, and governments with vested social and economic interests in maintaining their freshwater resources. The requirements of growing human populations and consumption, the wasteful use of water resources by much of the developed world, and the pollution of much of the world's useable freshwater by pollution and mismanagement of terrestrial systems means that freshwater ecosystems will likely remain imperiled for many years. But perhaps we have, at least, reached a point where we can begin to craft an effective strategy of reconciliation in an increasingly human-dominated landscape for the protection and management of freshwater resources and the priceless biological wealth they contain.

Melanie Stiassny is the Axelrod Research Curator in the Department of Ichthyology at the American Museum of Natural History and Adjunct Professor at Columbia University where she has active graduate and undergraduate teaching programs. Before coming to New York she was an Assistant Professor of Biology at Harvard University and taught there for five years. Her Ph.D. is from the University of London and she spent three years of post-doctoral research in the Netherlands before joining the faculty at Harvard University. Melanie has conducted extensive research throughout the World's tropical waters studying the evolution, behavior, and conservation of fishes. Freshwater fishes are among the most threatened of all the planet's creatures and many are becoming extinct even before they can be discovered. In the face of these growing threats her research aims at a synthesis of systematics, biogeography, and fish biology with strategies that integrate these into conservation planning. Increasingly work centers on issues of competition for freshwater resources and its impact on aquatic biodiversity loss. On the comparative anatomical side, processes and mechanisms of morphological transformation in ontogeny and phylogeny are an ongoing research interest. In addition to being Lead Curator for the Museum's new Hall of Ocean Life, Dr. Stiassny is a scientific advisor to various scientific and conservation organization such as the World Resources Institute, and the International Foundation for Science. She is a member of the National Council of the World Wildlife Fund, the Advisory Council of Conservation International's Center for Applied Biodiversity Science, and the World Commission on Protected Areas (WCPA) of IUCN-The World Conservation Union. She has served as an assigning Editor for the journal Conservation Biology and is a regular reviewer for numerous scientific journals and conservation publications.

David Strayer

Aquatic Ecologist, Institute of Ecosystem Studies, USA

David Strayer is a freshwater ecologist at the Institute of Ecosystem Studies (IES) in New York's Hudson Valley. He has worked on the distribution and ecological roles of freshwater invertebrates in lakes, streams, rivers, and ground waters. He and his colleagues at IES are studying the functioning of the Hudson River ecosystem, including its response to the zebra mussel invasion, and trying to understand what limits the distribution and abundance of increasingly endangered native mussels. He is the author of more than 100 scientific publications, including "The Pearly Mussels of New York State." Dr. Strayer received a B.S. in Zoology (with high honor) from Michigan State University, and earned his Ph.D. in Ecology and Evolutionary Biology at Cornell University.

Caroline Sullivan

Head of the Water Policy and Management Section, Centre for Ecology and Hydrology, Wallingford, UK

COMMUNITIES AND CATCHMENT STRATEGIES FOR FRESHWATER MANAGEMENT: SELECTED EXAMPLES FROM AROUND THE WORLD

The need for more effective strategies for freshwater management has now become globally recognized. Freshwater species loss is significantly higher than biodiversity losses from terrestrial ecosystems. Human population pressure and anthropocentric values have given rise to a situation where today there are almost no pristine freshwater bodies in any part of the world. Forty percent of total global river run-off is captured through various forms of hydraulic modification, and natural flow regimes in almost all major river systems retain little of their original form.

The commitment to sustainable development has underlined the need for a more responsible attitude to the maintenance of ecological integrity. Increasingly, national legislation and international agreements incorporate water allocations to support environmental water needs. At the same time, commitment to the Millennium Development Goals puts pressure on water managers to deliver better water services to those who are currently unserved, and this has given rise to what some have termed a "water crisis." This paper discusses some examples of new approaches to water management that attempt to address these problems in a more integrated way, while at the same time incorporating the views of a diverse range of stakeholders.

Caroline Sullivan is the Head of the Water Policy and Management Section at the Centre for Ecology and Hydrology, Wallingford, UK. She has lived and worked in a number of developing countries for over 20 years, including Guyana, Colombia, Greece, and Brunei. Originally qualified in Economics and Psychology, she holds an M.Sc. in Economic Development

Planning, and her Ph.D. investigated methods of environmental valuation relating to the use of non-timber forest products from tropical forests. Dr. Sullivan's main interest is in the relation between development and the environment, and her current research interests include water management, environmental valuation, and forestry issues. In particular, for a number of years she has worked on integrated water resource assessment methodologies and indicator development. She is also involved in work on vulnerability assessment relating to water resources. Dr. Sullivan has been involved in several projects on both forestry and watershed management funded by a number of different donors, and she is currently involved in projects in Africa, Asia, and the Caribbean. Dr. Sullivan is a member of the scientific committee for the DIVERSITAS cross-cutting network on freshwater biodiversity, and a member of the International Society for Ecological Economics.

Rebecca Tharme

Freshwater Ecologist, International Water Management Institute, Sri Lanka

Environmental Flow Assessment: Issues and Innovations

Water resource development continues to lead to the degradation of wetland systems — driven, among other factors, by alterations to their flow regimes. In response, a science of environmental flow assessment has become established, whereby the quantity and quality of water required for ecosystem maintenance are determined. Currently, over 200 methodologies are being applied in some 50 countries worldwide. Different policy and institutional backgrounds, basin development and management options, types of aquatic ecosystems, as well as socio-economic and resource contexts have necessitated such a range in alternative approaches to setting environmental flows. Several areas of innovation have emerged surrounding the diversity of paths adopted and there have been important paradigm shifts.

Among the evolving innovations is a multi-tier application of environmental flow methodologies to cater for ecosystem water requirements at different levels of resolution. Hydrology-based methodologies, the type of approach most commonly applied at the basin planning level, are advancing to ensure greater ecological relevance and transferability. Additionally, a natural flow paradigm has catalyzed an increasing shift from simplistic minimum flows to more explicit consideration of natural flow variability. At more detailed scales of assessment, hydrodynamic habitat modeling for target species is developing as only one of a far broader suite of tools that aims to address whole-ecosystem flow requirements, based on explicit links between changes in flow regime and biophysical response. The new body of more holistic methodologies has paved the way for multidisciplinary innovation in areas including hydrology-ecology modeling, scenario generation, and linking ecological change to socio-economic consequences for people's livelihoods. Rapid uptake of such innovations is under way in developing countries where, although environmental flow research is in its infancy, pressures on aquatic ecosystems and demands for further water resource development are tremendous. The opportunity exists to capitalize on such areas of innovation and strategically build the capacity to advance them.

Rebecca Tharme is a freshwater ecologist with 14 years experience in anthropogenic impacts on rivers and other wetland ecosystems in developed and developing countries. Ms. Tharme is a researcher at the International Water Management Institute, Sri Lanka, and Theme Leader of one of four multidisciplinary research themes on "Water Management and Environment." One of her areas of interest is in methodologies for assessing the environmental water requirements of aquatic ecosystems within basins. She co-leads one of the Ramsar Convention's Scientific and Technical Review Panel Working Groups, "Water Resource Management." She also leads another group on Agriculture, as research attention is increasingly focused on the interrelationships between wetlands and agricultural systems. Ms. Tharme earned a B.Sc. in Botany and Zoology, a B.Sc. Honours degree in Zoology and is due to submit a Ph.D. in Freshwater Ecology entitled "Ecologically relevant low flows for riverine benthic macroinvertebrates: characterization and implications for environmental flow assessment."

Tint Tun, Brian D. Smith, and Mya Than Tun

Associate Marine Biologist, Wildlife Conservation Society, Myanmar; Wildlife Conservation Society, Southeast Asia; Myanmar Department of Fisheries

Irrawaddy Dolphins and Castnet Fishermen: A Conservation Partnership in the Ayeyarwady River, Myanmar

*A "critically endangered" freshwater population of Irrawaddy dolphins (*Orcaella brevirostris*) survives isolated more than 1,000 km from the sea in a 372 km segment of the Ayeyarwady River, Myanmar. The most immediate threats to the population are probably accidental entanglement in gillnets and electrocution and depletion of prey from electric fishing. Additionally, the population is threatened by habitat degradation from gold mining operations and possibly mercury toxicity. Irrawaddy dolphins are generally revered by local people and they provide direct economic benefits to cast-net fishermen via their role in a human-dolphin cooperative fishery. The Wildlife Conservation Society, Whale and Dolphin Conservation Society, and Myanmar Department of Fisheries are developing plans for conserving the population. These plans entail enforcing laws that prohibit electricity fishing, establishing one or more protected areas where gillnetting would be eliminated or dramatically*

reduced, and monitoring the dolphin population and factors that threaten its survival. Management strategies will capitalize on the already positive attitude of fishermen to the dolphins by promoting the cooperative fishery. If deemed desirable, after learning more about the animals and consulting extensively with local fishermen, opportunities would be provided for income generation from small scale "ecotourism." The idea would be to establish a certification process where qualifying fishermen would be able to make extra money by taking small groups of tourists out in their boats to observe the dolphins and the cast-net fishing technique. This money would be an enormous help to these generally impoverished fishermen and may also be an option to partially compensate local fisheries departments and townships for lost revenue from permits no longer sold for gill netting concessions as these are eliminated on a stepwise basis.

Tint Tun is an Associate Marine Biologist with the Wildlife Conservation Society in his native country of Myanmar. His research efforts focus on pearl oysters, oysters, fishery, coral, and whale and dolphin research. He received an M.Sc. degree from the University of Yangon in 1986. From 1977 to 1986, he worked as an Apprentice Pearl Culturist at the People's Pearl and Fishery Corporation; as a Demonstrator in the Department of Marine Science at the University of Mawlamyine, from 1986 to 1992; and as a Pearl Culture Biologist in French Polynesia, from 1995 to 1996. In 2004, he joined the Wildlife Conservation Society office in Yangon.

Jake Vander Zanden
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Fly Fishing for Biodiversity: Taimen in Mongolia

Hucho taimen*, the world's largest salmonid, has suffered dramatic declines across Chinese and Russian portions of its historical range. Because the consumption of wild fish is not part of traditional Mongolian culture, many Mongolian rivers maintain healthy taimen populations, thus providing a unique fisheries conservation opportunity. Recreational taimen fishing from foreign tourists has expanded rapidly in the past decade. While this expansion of fishing could easily produce population declines, it may also provide an opportunity to develop a non-extractive fishery that provides local economic benefits, while simultaneously creating incentives for river conservation. We are presently developing a managed catch-and-release fishery for taimen in a major watershed in northwestern Mongolia. Concession units are being designated based on demographic and migration data being collected for taimen. Rights to catch-and-release fishing in these concession units are leased to outfitters, generating money for anti-poaching enforcement and community outreach. This project involves participation of diverse stakeholders — the local Buddhist leadership, fly fishing outfitters, the non-profit group Taimen Conservation Fund, scientists, and local community leaders in an effort to create incentives for protection of the river ecosystems that support taimen, thereby serving as a vehicle for river conservation.*

Jake Vander Zanden is currently an assistant professor at University of Wisconsin – Madison, Center for Limnology. Dr. Vander Zanden received his Ph.D. in Biology from McGill University in Montreal, Canada in 1999, and was awarded a Nature Conservancy David H. Smith Postdoctoral Fellowship at the University of California-Davis. He is currently involved in several projects involving the application of science to environmental management. Ongoing work includes the development of riparian buffer implementation policy for Wisconsin, management of aquatic invasive species, Lahontan cutthroat trout conservation and restoration in Sierra Nevada lakes, and evaluating the restoration potential of Great Lakes food webs.

Center for Biodiversity and Conservation American Museum of Natural History

In 1993, the American Museum of Natural History created the Center for Biodiversity and Conservation (CBC) to enhance the use of scientific data to mitigate threats to biodiversity. The CBC develops strategic partnerships to expand scientific knowledge about diverse species in critical ecosystems and to apply this knowledge to conservation; builds professional and institutional capacities for biodiversity conservation; and heightens public understanding and stewardship for biodiversity. Working both locally and around the world, the CBC develops model programs that integrate research, education, and outreach so that people — a key factor in the rapid loss of biodiversity — will become participants in its conservation.

The CBC's programs focus on areas of the world where biodiversity is richest and most threatened, as well as on taxa that have traditionally been neglected in the conservation process, such as invertebrates. The CBC has active projects in The Bahamas, Bolivia, Madagascar and southern Africa, Vietnam, and the United States. The CBC's focus on freshwater has included invertebrate research in Bolivia (resulting in the description of eight new species of caddisflies and six new species of stoneflies), herpetofauna research in Southeast Asia (including the description of 11 new species of amphibians from Vietnam), and a remote sensing/GIS mapping and watershed modeling project in central Vietnam.

Currently, CBC staff are working with this symposium's keynote speaker, Dr. Melanie Stiassny, in the Museum's Department of Ichthyology, and the Zoologische Museum Staatssammlung Munich in a program of geospatial analyses of western central African fishes. Satellite imagery and geospatial coverage data are being assimilated for the Congo basin to identify areas for biotic surveys and inventories as part of a field program in 2005. An integrated geospatial database that combines specimen and collection locality data with the assimilated satellite and geospatial coverage data will also be developed to assist in management of collections, sharing results with fellow researchers and the public, data analysis, and publishing results. This work will provide an important data management system that can assist in future analyses of the correlations between species distributions, biogeography, and habitat heterogeneity.

Learn more about the CBC: **http://cbc.amnh.org**

Raising awareness and promoting conservation action are also CBC imperatives, and through symposia, workshops, and publications we help to inform the public about biodiversity issues. To make the complex political and economic decisions necessary for the protection of global biological resources, people must have the scientific tools to identify and understand the mechanisms behind the threats to biodiversity. The CBC's role is to equip the world community to use these tools effectively.

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Known in the United States as World Wildlife Fund and recognized worldwide by its panda logo, WWF leads international efforts to protect endangered species and their habitats and to conserve the diversity of life on Earth. Now in its fifth decade, WWF, the global conservation organization, works in more than 100 countries around the world. For more information about WWF, visit http://www.worldwildlife.org/.

National Oceanic and Atmospheric Administration

NOAA is dedicated to enhancing economic security and national safety through the prediction and research of weather and climate-related events and providing environmental stewardship of our nation's coastal and marine resources. To learn more about NOAA, please visit http://www.noaa.gov/.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service is the principal Federal agency responsible for conserving, protecting and enhancing fish, wildlife and plants and their habitats for the continuing benefit of the American people. The Service manages the 95-million-acre National Wildlife Refuge System, which encompasses 544 national wildlife refuges, thousands of small wetlands and other special management areas. It also operates 69 national fish hatcheries, 63 Fish and Wildlife Management offices and 81 ecological services field stations. The agency enforces federal wildlife laws, administers the Endangered Species Act, manages migratory bird populations, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, and helps foreign governments with their conservation efforts. It also oversees the Federal Assistance program, which distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies. For more information about the U.S. Fish and Wildlife Service, visit our homepage at http://www.fws.gov/.

National Park Service

The National Park Service, a bureau within the U.S. Department of Interior, is charged with the responsibility to preserve, unimpaired, the natural and cultural resources and values of our nation's National Park System for the enjoyment, education, and inspiration of this and future generations. The National Park Service administers over 385 designated units of the National Park System, oversees a National Trails System, and cooperates and assists partners in the management of National Heritage Areas, Wild and Scenic River Systems and other natural and cultural heritage sites. The National Park System includes 40 units with significant marine resources including coral reef, temperate kelp forest, glacial fjord, rocky inter-tidal, estuarine, and arctic marine ecosystems. The Service manages over 4,000 miles of marine and Great Lakes shoreline for a total of 71 coastal and Great Lakes park units. For more information about the National Park Service and its programs, visit http://www.nps.gov.

National Biological Information Infrastructure, U.S. Geological Survey

The National Biological Information Infrastructure (NBII) is a broad, collaborative program to provide increased access to data and information on the nation's biological resources. Coordinated by the U.S. Geological Survey, the NBII links diverse, high-quality biological databases, information products, and analytical tools maintained by NBII partners and other contributors in government agencies, academic institutions, non-government organizations, and private industry. Resource managers, scientists, educators, and the general public use the NBII to answer a wide range of questions related to the management, use, or conservation of this nation's biological resources. For more information, please visit http://www.nbii.gov/

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