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Ulrich Saint-Paul • Horacio Schneider
Editors

Mangrove Dynamics and Management in North Brazil

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Editors

Prof. Dr. Ulrich Saint-Paul
Leibniz Center for
Tropical Marine Ecology
Fahrenheitstr. 6
28359 Bremen, Germany
ulrich.saint-paul@zmt-bremen.de

Prof. Dr. Horacio Schneider
Universidade Federal do Pará
Instituto de Estudos Costeiros
Campus de Bragança
Alameda Leandro Ribeiro s/n
68.600-000 Bragança/PA, Brazil
horacio@ufpa.br

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Foreword

Sheltered coastal marine and estuarine areas in the tropics are the sites of mangrove communities: highly productive systems that provide a variety of essential ecosystem services, including (1) processing of organic matter transported in run-off waters, (2) coastal protection against erosion, and (3) reproduction sites for a large array of marine and estuarine fauna. Scientific studies of mangrove ecosystems throughout the world have a long history, and as a result, we understand much of their ecology and physiology.

Presently, those systems are heavily impacted by human activities that have surpassed their tolerance limit. The impact derives from the increasing size of coastal cities and expansion of port services, and the large amount of human and industrial waste dumped into the rivers that feed coastal ecosystems with fresh water. Furthermore, the impact of sea level rise has to be included in the analyses of stability and maintenance of mangrove ecosystems.

The biotic productivity of mangroves provide food and other resources to the human populations that inhabit or make use of them. Intensity of human use is also increasing, approaching in some cases the limits of biological resources renewal. In order to develop sensible and effective management strategies leading to conservation of mangroves ecosystems services and maintain their productive capacity, it is necessary to integrate the local human populations depending on mangrove ecosystems for their subsistence.

Integrative studies of tropical ecosystems are essential to achieve conceptual advances in the understanding of their structure and function and to prepare for the impact of global change on ecosystems services. However, they constitute a technical and organizational challenge. Projects of this type need to be planned at a large scale and to develop over several years in order to produce meaningful and reliable results.

The study of coastal systems is particularly demanding within this context as they involve not only the complexities of natural systems but also a vast range of human interactions. Coastal regions are historically preferential sites for human occupation, and tend to be heavily populated, constituting the center of vigorous

economic activities. As a result, coastal ecosystems are also strongly impacted, being in many cases irretrievably destroyed.

The MADAM project was conceptualized as such an endeavor on one of the largest continuous mangrove areas in the world, the Amazonian ecoregion located in the tropical eastern South American coast, comprising an area of more than 23,000 km² (Sullivan Sealy and Bustamante 1999). It became a success story regarding the scale of the coordination required, its multidisciplinary and transdisciplinary character, and the integration of natural and social sciences, which produced a functional picture of the mangrove ecosystems in the coast of Pará State in Brazil. It has also been a model of how to develop international cooperative projects, in this case the cooperation of Brazil and Germany, leading to a productive and long-lasting investment in development of human resources.

The MADAM project has produced a large body of scientific information, as shown in the syntheses included in this book, but the most important result has been the sizable number of students influenced and educated within the project in both countries. In addition, and no less important, there has been the educational impact of the project on the local populations in many places along the Caeté River, where the project was centered for more than 10 years.

Beyond the scientific results, this book also provides information, guidelines, and examples on how to organize and develop multidisciplinary, international projects that lead to sensible and reliable management approaches for coastal systems conservation and ecologically sound use.

E. Medina

References

Sullivan Sealy K, Bustamante G (1999) Setting geographic priorities for marine conservation in Latin America and the Caribbean. The Nature Conservancy, Arlington, VA

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Contributors

Fernando Araújo Abrunhosa Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus Universitário de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, faraujo@ufpa.br

Ana Rosa da Rocha Araújo Universidade Federal de Sergipe, Centro de Biológico da Saude - CCBS; Núcleode Engenharia de Pesca - NEP. Av. Marechal Rondon, s/n Jardim Rosa Elze, 49100-000 São Cristóvão, SE, Brazil, anafriedaaraujo@yahoo.com.br

Audrey Barletta-Bergan Burgstr. 8, 21682 Stade, Germany, abarletta@gmx.de

Mário Barletta UFPE, Departamento de Oceanografia, Laboratório de Ecologia e Gerenciamento de Ecossistemas Costeiros e Estuarinos, Cidade Universitária, 50740-550 Recife, PE, Brazil, barletta@ufpe.br

Renata Souza de Barros Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil

Colin Robert Beasley Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, beasley@ufpa.br

Hermann Behling Department of Palynology and Climate Dynamics, Albrecht-von-Haller-Institute for Plant Sciences, University of Göttingen, Untere Karspüle 2, 37073 Göttingen, Germany, Hermann.Behling@bio.uni-goettingen.de

Uta Berger TU Dresden, Institute of Forest Growth and Forest Computer Sciences, Postfach 1117, 01735 Tharandt, Germany, uta.berger@tu-dresden.de

Michael Bock German Aerospace Center, German Remote Sensing Data Center, Environment and Security, Münchner Str. 20, 82234 Oberpfaffenhofen-Wessling, Germany, Michael.Bock@dlr.de

Marcelo Cohen Faculty of Oceanography, Federal University of Pará, Rua Augusto Corrêa 1, Guama, 66075-110 Belém/PA, Brazil, mcohen@ufpa.br

Karen Diele Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, karen.diele@zmt-bremen.de

Thorsten Dittmar Max Planck Research Group – Marine Geochemistry, Carl von Ossietzky University, ICBM, PO Box 2503, 26111 Oldenburg, Germany, tdittmar@mpi-bremen.de

Roberto Vilhena do Espírito Santo Universidade Federal do Pará, Centro de Ciências Biológicas, Laboratorio de Biologia Pesqueira e Manejo de Recursos Aquaticos, Avenidada Perimetral 2651, 66077-530 Belém, PA, Brazil, r_vilhena@yahoo.com.br

Marcus Emanuel Barroncas Fernandes Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil

Elder Augusto Guimarães Figueira Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança/PA, Brazil

Martha L. Fontalvo-Herazo Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany

Marion Glaser Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, marion.glaser@zmt-bremen.de

Victoria Isaac Universidade Federal do Pará, Centro de Ciências Biológicas, Laboratorio de Biologia Pesqueira e Manejo de Recursos Aquaticos, Avenida Perimetral 2651, 66077-530 Belém, PA, Brazil, biologiapesqueira@yahoo.com.br

Boris P. Koch University of Applied Sciences, An der Karlstadt 8, 27568 Bremerhaven, Germany, boris.koch@awi.de; Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, 27570 Bremerhaven, Germany

Volker Koch Universidad Autónoma de Baja California Sur, Depto. Biol. Marina, Carretera al Sur, km 5.5, Ap. Postal 19-B, La Paz, B.C.S, C. P.23080, México, vokoch@uabcs.mx

Gesche Krause Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, gesche.krause@zmt-bremen.de

Uwe Krumme Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, uwe.krumme@zmt-bremen.de

Rubén J. Lara Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, ruben.lara@zmt-bremen.de

Jô de Farias Lima Embrapa Amapá, Rodovia Juscelino Kubitschek, km5, nº 2600, Caixa Postal 10, Macapá, 68903-149 AP, Brazil, jodeflima@yahoo.com.br

Ernesto Medina Instituto Venezolano de Investigaciones Científicas, Centro de Ecología, 1020-A Caracas, Venezuela, emedina@ivic.ve

Ulf Mehlig Universidade Federal do Pará, Campus Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, ulf@ufpa.br

Kely dos Reis Melo Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil

Moirah P.M. Menezes Universidade Federal do Pará, Campus Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, moirah@ufpa.br

Inga Nordhaus Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, Inga.nordhaus@zmt-bremen.de

Rosete da Silva Oliveira Universidade Federal do Pará, Campus Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, rosete_dasilvaoliveira@yahoo.com.br

Cyril Piou INRA, Pôle d'Hydrobiologie, Ecologie Comportementale et Biologie des Populations de Poissons, Quartier Ibarron, 64310 Saint Pée sur Nivelle, France, cpiou@st-pee.inra.fr

Annegret Reise Instituto de Biología Marina, Campus Isla Teja, Universidad Austral de Chile, Avenida Ines Haverbeck 11-13, Valdivia, Chile, anneken.reise@gmx.de

Ingo Puch Rojo Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany

Ulrich Saint-Paul Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, ulrich.saint-paul@zmt-bremen.de

Ulrich Salzmann Northumbria University, School of the Built and Natural Environment, Ellison Building, NE1 8ST Newcastle upon Tyne, UK, ulrich.salzmann@northumbria.ac.uk

Iracilda Sampaio Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, ira@ufpa.br

Simôni Santos Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil

Horacio Schneider Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, horacio@ufpa.br

Dirk Schories Instituto de Biología Marina, Campus Isla Teja, Universidad Austral de Chile, Avenida Ines Haverbeck 11-13, Valdivia, Chile, dirk.schories@gmx.de

Darlan de Jesus de Brito Simith Universidade Federal do Pará, Instituto de Estudos Costeiros, Campus de Bragança, Alameda Leandro Ribeiro s/n, 68600-000 Bragança, PA, Brazil, simithdjb@hotmail.com

Horst Sterr Universität Kiel, Geographisches Institut, Ludewig-Meyn-Str 14, 24098 Kiel, Germany, sterr@geographie.uni-kiel.de

Claudio Szlafsztein University Federal of Pará, NUMA, Cidade Universitária, Augusto Correa 1, 66075-900 Belém, Pará, Brazil, iosele@ufpa.br

Vincent Vedel Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany

Matthias Wolff Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany, matthias.wolff@zmt-bremen.de