

The editors express their appreciation to all authors for the quality of their work and cooperation during the preparation of this text. We trust that this volume will be an asset for all persons, professional and public alike, who have an interest in the ecology, conservation and management of wetland ecosystems. Special gratitude is extended to Lafayette College, The Pennsylvania State University, Grove City College and the Pennsylvania Academy of Science for their support in the development of this book. The editors extend heartfelt thanks to their spouses for their encouragement and support during the preparation of this volume.

Shyamal K. Majumdar
E. Willard Miller
Fred J. Brenner

Editors
March 1998

ACKNOWLEDGEMENT

The publication of this book was aided by contributions from the E. Willard and Ruby S. Miller book publication fund.

Ecology of Wetlands And Associated Systems

Table of Contents

Preface	V
Acknowledgement	VI
Foreword John C. Oliver III, Secretary of Pennsylvania Department of Conservation and Natural Resources and Robert H. Hill, Biodiversity Coordinator, Harrisburg, PA	XIII
 Part One: Wetland Types and Ecology	
Chapter 1: WETLAND MAPPING	
<i>Kenneth M. Klemow, Department of Biology, Wilkes University, Wilkes Barre, PA</i>	
Chapter 2: WETLAND TYPES	
<i>Brij Gopal, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India</i>	27
Chapter 3: CLASSIFICATION AND INTEGRATION OF WETLANDS IN URBAN ENVIRONMENTS	
<i>Fred J. Brenner and Elizabeth Mountz, Department of Biology, Grove City College, Grove City, PA</i>	35
Chapter 4: ECOLOGY AND STATUS OF TIDAL WETLANDS IN NORTH AMERICA	
<i>John L. Gallagher, Halophyte Biotechnology Center, College of Marine Studies, University of Delaware, Lewes, DE</i>	47
Chapter 5: WETLANDS IN PENNSYLVANIA: SPATIAL PATTERNS AND REMEDIATION TECHNIQUES	
<i>John E. Benhart, Department of Geography and Earth Sciences, Shippensburg University, Shippensburg, PA and John E. Benhart, Jr., Geography and Regional Planning Department, Indiana University of Pennsylvania, Indiana, PA</i>	50

Chapter 6: HOW TO TELL WETLANDS APART: A BOG VERSUS A FEN <i>Steven J. Ropski, Department of Biology, Gannon University, Erie, PA</i>	78
Chapter 7: ECOLOGY OF THE CONIFER PEATLANDS OF NORTHERN NEW JERSEY <i>Eric F. Karlin, School of Theoretical and Applied Science, Ramapo College of New Jersey, Mahwah, NJ</i>	84
Chapter 8: ECOLOGY OF INDIAN WETLANDS <i>R.S. Ambasht and N.K. Ambasht, Centre of Advanced Study, Botany Department, Banaras Hindu University, Varanasi, India</i>	104
Part Two: Wetland Environment and Ecosystem	
Chapter 9: WETLAND ECOSYSTEM DEVELOPMENT: AN EVALUATION OF THE CONCEPT OF WETLAND PLANT SUCCESSION <i>John M. Campbell, Department of Biology, Mercyhurst College, Erie, PA</i>	117
Chapter 10: A MODEL TO LOCATE CONSTRUCTED WETLANDS IN AN ECOCENTRIC FARM DESIGN <i>Bruce C. Dickson, Confluence Ecological, Reno, PA</i>	31
Chapter 11: LINKAGES BETWEEN HYDROLOGY AND NITROGEN BIOGEOCHEMISTRY IN RIPARIAN WETLANDS <i>Christopher P. Cirno, Department of Geology, State University of New York, College of Cortland, Cortland, NY</i>	144
Chapter 12: RUNOFF PROCESSES IN TEMPERATE HEADWATER WETLANDS <i>Colin H. Taylor, Department of Geography, Trent University, Peterborough, Ontario, Canada</i>	169
Chapter 13: HYDRIC SOIL DEVELOPMENT IN DEPRESSIONAL WETLANDS: A CASE STUDY FROM SURFACE MINED LANDSCAPES <i>Robert B. Atkinson, Department of Biology, Chemistry, and Environmental Science, Christopher Newport University, Newport News, VA, W. Lee Daniels, Department of Crop and Soil Environmental</i>	

<i>Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA and John Cairns Jr., Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA</i>	182
Chapter 14: ENVIRONMENTAL ASPECTS OF THE WETLANDS <i>Apurba Sarkar, Project Directorate for Cropping Systems Research, Modipuram, Meerut, India</i>	198
Chapter 15: THE DYNAMIC OKAVANGO <i>Dan Miller, Water Resources Engineer, Stanley Consultants Inc., Muscatine, IA</i>	215
Part Three: Biological Adaptations to the Wetland Systems	
Chapter 16: POPULATION BIOLOGY OF WETLAND PLANTS <i>John M. Bernard, Department of Biology, Ithaca College, Ithaca, NY</i>	228
Chapter 17: MYCORRHIZAL RELATIONSHIPS OF WETLANDS AND RIVERS ASSOCIATED PLANTS <i>K.G. Mukerji and Mandeep, Applied Mycology Laboratory, Department of Botany, University of Delhi, Delhi, India</i>	240
Chapter 18: VEGETATION PATTERNS AND ENVIRONMENTAL RELATIONSHIPS IN AN ARCTIC RIPARIAN WETLAND <i>C.M. Pearce, Department of Geography, University of Western Ontario, London, Ontario, Canada</i>	258
Chapter 19: THE SUITABILITY OF CONSTRUCTED WETLANDS AS AMPHIBIAN HABITAT <i>C.R. Bursey, Department of Biology, The Pennsylvania State University, Shenango Valley Campus, Sharon, PA</i>	281
Chapter 20: PREDICTING HABITAT FOR WETLAND- DEPENDENT REPTILES AND AMPHIBIANS <i>Alison L. Whitlock, Department of Forestry and Wildlife, University of Massachusetts, Amherst, MA</i>	287
Chapter 21: ENHANCEMENT OF TIDAL WETLANDS FOR WILDLIFE HABITAT AND MOSQUITO CONTROL <i>Roger J. Wolfe, Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, Dover, DE</i>	297

Chapter 22: BIRDS AS INDICATORS OF WETLAND ECOSYSTEMS <i>Mary Jo Casalena, Pennsylvania Game Commission, Harrisburg, PA</i>	313	<i>Grove City College, Grove City, PA</i>	432
Chapter 23: WETLAND HABITATS FOR WILDLIFE OF THE CHESAPEAKE BAY <i>Matthew C. Perry, Patuxent Wildlife Research Center, Laurel, MD</i>	332	Chapter 30: SALT CEDAR INVASION IN DESERT WETLANDS OF THE SOUTHWESTERN UNITED STATES: ECOLOGICAL AND POLITICAL IMPLICATIONS <i>Jeffrey E. Lovich and Roland C. De Gouvenain, Bureau of Land Management, North Palm Springs, CA</i>	447
Chapter 24: WETLAND MAMMALS <i>Thomas L. Serfass and Robert P. Brooks, School of Forest Resources, The Pennsylvania State University, Penn State Cooperative Wetlands Center, University Park, PA</i>	350	Chapter 31: THE IMPACT OF MINING AND OTHER NONPOINT SOURCES ON THE ECOLOGY OF HEADWATER STREAMS AND ASSOCIATED WETLANDS <i>Fred J. Brenner, Rachel J. Becker and Peter J. Sharp, Biology Department, Grove City College, Grove City, PA</i>	468
Part Four: Environmental Contaminants and Impacts		Part Five: Wetland Values, Management and Restoration	
Chapter 25: INTERSPECIFIC VARIABILITY OF HEAVY METALS IN BIOTIC MATRICES OF EAST COAST OF INDIA FOR ITS SUSTAINABLE CONSERVATION AND MANAGEMENT <i>B. Bhattacharya, Department of Metallurgical Engineering, Jadavpur University, Calcutta, India and S.K. Sarkar, Department of Marine Science, Calcutta University, Calcutta, India</i>	359	Chapter 32: ECONOMIC VALUE OF WETLANDS <i>T. H. Stevens, Department of Resource Economics, University of Massachusetts, Amherst, MA</i>	486
Chapter 26: PERSPECTIVES ON THE USE OF DAPHNIDS IN AQUATIC TOXICOLOGY OF PESTICIDES <i>Sameeh A. Mansour, Environmental Toxicology Research Unit, Pesticide Chemistry Department, National Research Centre, Dokki, Cairo, Egypt</i>	372	Chapter 33: CONSTRUCTING WETLANDS FOR PASSIVE TREATMENT OF COAL MINE DRAINAGE <i>Robert Kleinmann, U.S. Dept. of Energy, Federal Energy Technology Center, Pittsburgh, PA</i>	497
Chapter 27: RIVERINE INPUT OF CHLORINATED HYDROCARBONS IN THE COASTAL POLLUTION <i>A. Sarkar, Chemical Oceanography Division, National Institute of Oceanography, Dona Paula, Goa, India and J.M. Everaarts, Department of Biogeochemistry and Toxicology, Netherlands Institute for Sea Research, The Netherlands</i>	400	Chapter 34: HOW DO WE GET WETLAND SCIENCE INTO THE REAL WORLD? THE ROLE OF WETLAND EDUCATION <i>William A. Niering, Connecticut College, New London, CT and Jon A. Kusler, The Association of Wetland Managers, Inc., Berne, NY</i>	510
Chapter 28: AGRICULTURE CONTAMINANTS IN AQUATIC SYSTEMS IN TAMIL NADU AND ITS IMPACT <i>A.J.A. Ranjit Singh and C. Padmalatha, , Department of Biology, Sri Paramakalyani College, Alwarkurichi-Tirunelveli Dist, Tamil Nadu, India</i>	424	Chapter 35: ADVANCES AND RETREAT: A POLICY REPORT AND ANALYSIS FOR WETLANDS IN ONTARIO <i>M.J. Bardecki, Ryerson Polytechnic University, Toronto, Canada</i>	529
Chapter 29: AGRICULTURAL IMPACTS ON HEADWATER STREAMS AND ASSOCIATED WETLANDS <i>Fred J. Brenner, Holly J. Whitbeck and Michelle M. Langdon,</i>		Chapter 36: PROTECTING FRESHWATER WETLANDS IN NEW YORK: STATE MAPPING AND LOCAL RESPONSE <i>George A. Schnell, Department of Geography, State University of New York at New Paltz, New Paltz, NY and Mark Monmonier, Department of Geography, Syracuse University, Syracuse, NY</i>	540
		Chapter 37: WETLANDS AND FLOOD CONTROL	

FOREWORD

John C. Oliver III, *Secretary*
and

Robert J. Hill, *Biodiversity Coordinator*
Pennsylvania Department of Conservation and Natural Resources
Harrisburg, PA 17105-8552

<i>Kenneth M. Klemow and Thomas M. Walski, Department of Biology, Wilkes University, Wilkes-Barre, PA</i>	555
Chapter 38: RESTORATION OF THE KISSIMMEE RIVER ECOSYSTEM IN CENTRAL FLORIDA, USA <i>Joseph W. Koebel, Jr., South Florida Water Management District, West Palm Beach, FL, Steven C. Harris, Department of Biology, Clarion University, Clarion, PA, and D. Albrey Arrington, Ecosystem Restoration Department, South Florida Water Management District, West Palm Beach, FL</i>	587
Chapter 39: WETLAND RESTORATION ON THE PLATTE RIVER FLOODPLAIN IN NEBRASKA <i>Paul J. Currier, Platte River Whooping Crane Maintenance Trust Inc., Wood River, NE</i>	611
Chapter 40: WETLANDS AND FISHERIES RESOURCES OF THE MISSISSIPPI RIVER <i>Robert J. Sheehan, Fisheries Research Laboratory and Department of Zoology, Southern Illinois University-Carbondale, IL and Mark Konikoff, Department of Biology, University of Southeastern Louisiana, Lafayette, LA</i>	628
Chapter 41: WETLANDS IN NEPAL: STATUS, SIGNIFICANCE AND MANAGEMENT <i>P.K. Jha, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal and P. Lacoul, Department of Biological Sciences, Kathmandu University, Dhulikhel, Nepal</i> .	548
Subject Index	670

In 1586, an unidentified French artist of Sir Francis Drake's expedition produced one of the earliest accounts of wetlands in North America. It is a simple ochre wash, dotted with dozens of dark-brown specks representing a swarm of mosquitoes. This record was emblematic of our attitude toward wetlands. They were viewed as unproductive, disease-inducing sites that generated only foul-smelling swamp gas. For several successive centuries, wetlands were dumped on, drained, or filled without much thought. Our behavior in North America was a sad extension of historical, global wetland destruction.

The result has been universal loss of wetlands. Research indicates that half of the US's wetlands have been converted to uplands since the Colonial Period. In the Commonwealth of Pennsylvania, 56% of our wetland habitat has disappeared at our hands since the 1780s. As our wetlands vanish, so do a substantial number of plant and animal species that inhabit them. In fact, much of the Commonwealth's flora and fauna are wetland-dependent, that is, they spend more than two-thirds of their time in wet habitats. Moreover, 84% of Pennsylvania's amphibians, 46% of birds, 44% of reptiles, and 37% of vascular plants are directly tied to wetlands. These numbers are typical of many other states and nations.

Despite a decrease in the rate of loss from earlier periods, destruction of wetlands still outdistances gains in many regions around the world. For example, the Chesapeake Bay Foundation estimates that the Chesapeake Bay Watershed—feeding the nation's largest estuary and one of the world's most productive—is losing 4,500 acres of wetlands a year. These losses are attributed to government exemption of many activities in wetlands, permit approvals without review, and unpermitted wetland fills. This dispossession is lamentable. With habitat degradation and loss, biological diversity at all levels—landscape, species and genetic—is adversely impacted. Simply put, wetlands harbor critical habitats and ecosystems and are at risk. They also serve as natural sponges in times of heavy rain. It is imperative that we take wetland conservation seriously.

Although much is known about wetlands, our knowledge is still imperfect. Gaps in our understanding include details of ecological dynamics; the significance of landscape position; current status, trends and quality of wetlands; and wetland conservation, construction, and restoration. Valuable insights into these and other issues lie in the many chapters of this book. For instance, perspectives on agricultural and contaminant effects on wetlands, non-point source pollution,