Chapter 1

Wetlands: Human History, Use, and Science

Wetlands, landscape features found in almost all parts of the world, are known as "the kidneys of the landscape" and "ecological supermarkets" to bring attention to the important values they provide. Although many cultures have lived among and even depended on wetlands for centuries, the modern history of wetlands is fraught with misunderstanding and fear, as described in much of our Western literature. Wetlands have been destroyed at alarming rates throughout the developed and developing worlds. Now, as their many values are being recognized, wetland conservation and protection have become the norm in many parts of the world. Wetlands have properties that are not adequately covered by present terrestrial and aquatic ecology, making a case for wetland science as a unique discipline encompassing many fields, including terrestrial and aquatic ecology, chemistry, hydrology, and engineering. Wetland management, as the applied side of wetland science, requires an understanding of the scientific aspects of wetlands balanced with legal, institutional, and economic realities. As interest in wetlands has grown, so too have professional organizations and agencies that are concerned with wetlands, as well as the amount of journals and literature on wetland science.

Wetlands are among the most important ecosystems on Earth. In the great scheme of things, the swampy environment of the Carboniferous period produced and preserved many of the fossil fuels on which our society now depends. In more recent biological and human time periods, wetlands have been valuable as sources, sinks, and transformers of a multitude of chemical, biological, and genetic materials. Although the value of wetlands for fish and wildlife protection has been known for a century, some of the other benefits have been identified more recently.

Wetlands are sometimes described as ''the kidneys of the landscape'' because they function as the downstream receivers of water and waste from both natural and human sources. They stabilize water supplies, thus ameliorating both floods and drought. They have been found to cleanse polluted waters, protect shorelines, and recharge groundwater aquifers.

Wetlands also have been called ''ecological supermarkets'' because of the extensive food chain and rich biodiversity that they support. They play major roles in the landscape by providing unique habitats for a wide variety of flora and fauna. Now that we have become concerned about the health of our entire planet, wetlands are being described by some as important carbon sinks and climate stabilizers on a global scale.

These values of wetlands are now recognized worldwide and have led to wetland conservation, protection laws, regulations, and management plans. But our history with wetlands had been to drain, ditch, and fill them, never as quickly or as effectively as was undertaken in countries such as the United States beginning in the mid-1800s.

Wetlands have become the *cause célèbre* for conservation-minded people and organizations throughout the world, in part because they have become symptoms of our systematic dismantling of our water resources and in part because their disappearance represents an easily recognizable loss of natural areas to economic ''progress.'' Scientists, engineers, lawyers, and regulators are now finding it both useful and necessary to become specialists in wetland ecology and wetland management in order to understand, preserve, and even reconstruct these fragile ecosystems. This book is for these aspiring wetland specialists, as well as for those who would like to know more about the structure and function of these unique ecosystems. It is a book about wetlands—how they work and how we manage them.

Human History and Wetlands

There is no way to estimate the impact humans have had on the global extent of wetlands except to observe that, in developed and heavily populated regions of the world, the impact has ranged from significant to total. The importance of wetland environments to the development and sustenance of cultures throughout human history, however, is unmistakable. Since early civilization, many cultures have learned to live in harmony with wetlands and have benefited economically from surrounding wetlands, whereas other cultures quickly drained the landscape. The ancient Babylonians, Egyptians, and the Aztec in what is now Mexico developed specialized systems of water delivery involving wetlands. Major cities of the world, such as Chicago and Washington, D.C., in the United States, Christchurch, New Zealand, and Paris, France, stand on sites that were once part wetlands. Many of the large airports (in Boston, New Orleans, and J. F. Kennedy in New York, to name a few) are situated on former wetlands.

While global generalizations are sometimes misleading, there was and is a propensity in Eastern cultures not to drain valuable wetlands entirely, as has been done in the West, but to work within the aquatic landscape, albeit in a heavily managed way. Dugan (1993) makes the interesting comparison between *hydraulic civilizations*

(European in origin) that controlled water flow through the use of dikes, dams, pumps, and drainage tile, partially because water was only seasonally plentiful, and *aquatic civilizations* (Asian in origin) that better adapted to their surroundings of water-abundant floodplains and deltas and took advantage of nature's pulses such as flooding. It is because the former approach of controlling nature rather than working with it is so dominant today that we find such high losses of wetlands worldwide.

Wetlands have been and continue to be part of many human cultures in the world. Coles and Coles (1989) referred to the people who live in proximity to wetlands and whose culture is linked to them as *wetlanders*. Some of these cultures and users of wetlands are illustrated in eighteen photographs in this chapter (Figures 1.1 through 1.18). Figures 1.1 through 1.7 show human cultures or settings around the world that have depended on wetlands, sometimes for centuries. Figures 1.8 through 1.11 show some of the many food products that are harvested from wetlands while Figures 1.12 through 1.16 illustrate the use of wetlands as sources of fuel, building materials, and even household goods. Most recently, wetlands have become the foci for ecotourism in many developing and developed parts of the world (Figure 1.17 through 1.18).

Sustainable Cultures in Wetlands

The Camarguais of southern France (Fig. 1.1), the Cajuns of Louisiana (Fig. 1.2), the Marsh Arabs of southern Iraq (Fig. 1.3), many Far Eastern cultures (Fig. 1.4), and the Native Americans in North America (Figs. 1.5 and 1.6) have lived in harmony with wetlands for hundreds if not thousands of years. These are the true wetlanders. For example, the Sokaogon Chippewa in Wisconsin have, for centuries, harvested and reseeded wild rice (*Zizania aquatica*) along the littoral zone of lakes and streams. They have a saying that ''wild rice is like money in the bank.'' Wetlands were often used as places of cultural solitude and reverence, as with the Mont St. Michel, a Benedictine monastery, built between the 11th and 16th centuries in northern France (Fig. 1.7).

Food from Wetlands

Domestic wetlands such as rice paddies feed an estimated half of the world's population (Fig. 1.8). Countless other plant and animal products are harvested from wetlands throughout the world. Many aquatic plants besides rice such as Manchurian wild rice (*Zizania latifolia*) are harvested as vegetables in China (Fig. 1.9). Cranberries are harvested from bogs, and the industry continues to thrive today in North America (Fig. 1.10). Coastal marshes in northern Europe, the British Isles, and New England were used for centuries and are still used today for grazing of animals and hay production.

Wetlands can be an important source of protein. The production of fish in shallow ponds or rice paddies developed several thousands of years ago in China and Southeast Asia, and crayfish harvesting is still practiced in the wetlands of Louisiana and the Philippines. Shallow lakes and wetlands are an important provider of protein in many parts of sub-Saharan Africa (Fig. 1.11).

Figure 1.1 The Camargue region of southern France in the Rhone River delta is an historically important wetland region in Europe where Camarguais have lived since the Middle Ages. *(Photograph by Tom Nebbia, Horseshoe, North Carolina, reprinted by permission.)*

Figure 1.2 A Cajun lumberjack camp in the Atchafalaya Swamp of coastal Louisiana. American Cajuns are descendants of the French colonists of Acadia (present-day Nova Scotia, Canada), who were forced out of Nova Scotia by the English and moved to the Louisiana delta in the last half of the 18th century. Their society and culture flourished within the bayou wetlands. *(Photograph courtesy of the Louisiana Collection, Tulane University Library, New Orleans, reprinted by permission.)*

Peat and Building Materials

The Russians, Finns, Estonians, and Irish, among other cultures, have mined their peatlands for centuries, using peat as a source of energy on small-scale production (Fig. 1.12) and in large-scale extraction processes (Fig. 1.13). *Sphagnum* peat is now harvested for horticultural purposes throughout the world. In southwestern New Zealand, for example, surface *Sphagnum* has been harvested since the 1970s for export as a potting medium (Fig. 1.14). Reeds and even the mud from coastal and

Figure 1.3 The Marsh Arabs of southern Iraq lived for centuries on artificial islands in marshes at the confluence of the Tigris and Euphrates rivers. The marshes were mostly drained by Saddam Hussein in the 1990s and are now being restored (see Chapter 12).

Figure 1.4 Interior wetlands in Weishan County, Shandong Province, China, where approximately 60,000 people live amid wetland-canal systems and harvest aquatic plants for food and fiber. *(Photograph by W. J. Mitsch.)*

inland marshes have been used for thatching for roofs in Europe, Iraq, Japan, and China, as well as wall construction, fence material, lamps, and other household goods (Figs. 1.15 and 1.16). Coastal mangroves are harvested for timber, food, and tannin in many countries throughout Indo-Malaysia, East Africa, and Central and South America.

Figure 1.5 Native American "ricers" from the Sokaogon Chippewa Reservation poling and "knocking" wild rice (*Zizania aquatica*) as they have for hundreds of years on Rice Lake in Forest County, Wisconsin. *(Photograph by R. P. Gough, reprinted by permission.)*

Figure 1.6 Several Native American tribes have lived in and around the wetlands of southern Florida, including the Florida Everglades. These include the Calusa Indians, who disappeared as a result of imported European disease, and later the Seminole (Miccosukee) tribe that moved south to the Everglades in the 19th century while being pursued by the U.S. Army during the Seminole Indian wars. They never surrendered. The Miccosukee adapted to living in hammock-style camps spread throughout the Everglades and relied on fishing, hunting, and harvesting of native fruits from the hammocks. *(Photograph by W. J. Mitsch, panorama at Miccosukee Indian Village, Florida Everglades.)*

Figure 1.7 Mont St. Michel, a Benedictine monastery, built between the 11th and 16th centuries, sits amid the coastal mudflats and salt marshes between Normandy and Brittany in northwestern France. Entry to the island, now a UNESCO World Heritage site, is through a land bridge that crosses the wetlands. ***(Photograph by A. Mauxion, reprinted by permission.)***

Figure 1.8 Rice production occurs in ''managed'' wetlands throughout Asia and other parts of the world. Half of the world's population is fed by rice paddy systems. ***(Photograph by W. J. Mitsch.)***

Figure 1.9 Wetland plants such as *Zizania latifolia* are harvested and sold in markets such as this one in Suzhou, Jiangsu Province, China. This and several other aquatic plants are cooked and served as vegetables in China. *(Photograph by W. J. Mitsch.)*

Figure 1.10 Cranberry wet harvesting is done by flooding bogs in several regions of North America. The cranberry plant (*Vaccinium macrocarpon*) is native to the bogs and marshes of North America and was first cultivated in Massachusetts. It is now also an important fruit crop in Wisconsin, New Jersey, Washington, Oregon, and parts of Canada. *(Photograph courtesy of Ocean Spray Cranberries, Inc., Lakeville-Middleboro, Massachusetts.)*

Figure 1.11 Humans use the wetlands of sub-Saharan Africa for sustenance, as with this man fishing for lung fish (*Proptopterus aethiopicus*) in Lake Kanyaboli, western Kenya. *(Photograph by K. M. Mavuti, reprinted by permission.)*

Figure 1.12 Harvesting of peat or "turf" as a fuel has been a tradition in several parts of the world, as shown by this scene of "turf carts" in Ireland.

Wetlands and Ecotourism

A modern version of wetland use is through ecotourism. Wetlands have been the focus of several countries' attempts to increase tourist flow into their countries (Figs. 1.17 and 1.18). The Okavango Delta in Botswana is one of the natural resource jewels of Africa, and protection of this wetland for tourists and hunters has been a

Figure 1.13 Large-scale peat mining in Estonia. ***(Photograph by W. J. Mitsch.)***

Figure 1.14 ***Sphagnum*** **moss harvesting in Westland, South Island, New Zealand for gardens and potting of plants.** ***(Photograph by C. Pugsley, New Zealand Department of Conservation, Wellington, reprinted by permission.)***

priority in that country since the 1960s. Local tribes provide manpower for boat tours (in dugout canoes called mokoros) through the basin and assist with wildlife tours on the uplands as well. In Senegal, west Africa, there is keen interest in attracting European birder tourists to the mangrove swamps along the Atlantic coastline. The advantage of ecotourism as a management strategy is obvious—it provides income to

Figure 1.15 A ''Wetland House'' in the Ebro River Delta Region on the Mediterranean Sea, Spain. The walls are made from wetland mud, and the roof is thatched with reed grass and other wetland vegetation. ***(Photograph by W. J. Mitsch.)***

Figure 1.16 Floor lamps developed from Yosi (reedgrass; ***Phragmites australis*****), Lake Biwa, Japan.** ***(Lamps designed by Mr. Morino; photograph by B. Cleveland, reprinted by permission.)***

Figure 1.17 Several rural communities exist in the vast, seasonally flooded Okavango Delta of northern Botswana in southern Africa. The wetlands attract tourists, as shown in this illustration, and also wildlife hunting, in addition to providing basic sustenance to these communities. ***(Photograph by W. J. Mitsch.)***

Figure 1.18 Interest in the wetlands that surround Lake Biwa in Shiga Prefecture, Japan, is intense, as shown by this photograph of participants at a winter 2006 international wetlands forum. ***(Photograph by W. J. Mitsch.)***

the country where the wetland is found without requiring or even allowing resource harvest from the wetlands. The potential disadvantage is that if the site becomes too popular, human pressures will begin to deteriorate the landscape and the very ecosystem that initially drew the tourism.

Literary References to Wetlands

With all of these valuable uses, not to mention the aesthetics of a landscape in which water and land often provide a striking panorama, one would expect wetlands to be revered by humanity; this has certainly not always been the case. Wetlands have been depicted as sinister and forbidding, and as having little economic value throughout most of history. For example, in the *Divine Comedy*, Dante describes a marsh of the Styx in Upper Hell as the final resting place for the wrathful:

> Thus we pursued our path round a wide arc of that ghast pool,
> Between the soggy marsh and arid shore,
> Still eyeing those who gulp the marish [marsh] foul.
>
> —Dante Alighieri

Centuries later, Carl Linnaeus, crossing the Lapland peatlands, compared that region to that same Styx of Hell:

> Shortly afterwards began the muskegs, which mostly stood under water; these we had to cross for miles; think with what misery, every step up to our knees. The whole of this land of the Lapps was mostly muskeg, hinc vocavi Styx. Never can the priest so describe hell, because it is no worse. Never have poets been able to picture Styx so foul, since that is no fouler.
>
> —Carl Linnaeus, 1732

In the 18th century, an Englishman who surveyed the Great Dismal Swamp on the Virginia–North Carolina border and is credited with naming it described the wetland as:

> [a] horrible desert, the foul damps ascend without ceasing, corrupt the air and render it unfit for respiration. . . . Never was Rum, that cordial of Life, found more necessary than in this Dirty Place.
>
> —Colonel William Byrd III (1674–1744), "Historie of the Dividing Line Betwixt Virginia and North Carolina" in *The Westover Manuscripts*, written 1728–1736, Petersburg, VA; E. and J. C. Ruffin, printers, 1841, 143 pp.

Even those who study and have been associated with wetlands have been belittled in literature:

> Hardy went down to botanise in the swamp, while Meredith climbed towards the sun. Meredith became, at his best, a sort of daintily dressed Walt Whitman: Hardy became a sort of village atheist brooding and blaspheming over the village idiot.
>
> —G. K. Chesterton (1874–1936), Chapter 12 in *The Victorian Age in Literature*, Henry Holt and Company, New York, 1913

The English language is filled with words that suggest negative images of wetlands. We get *bogged down* in detail; we are *swamped* with work. Even the mythical *bogeyman*, the character featured in stories that frighten children in many countries, may be associated with European bogs. Grendel, the mythical monster in one of the oldest surviving pieces of Old English literature and Germanic epic, *Beowulf*, comes from the peatlands of present-day northern Europe:

> Grendel, the famous stalker through waste places, who held the rolling marshes in his sway, his fen and his stronghold. A man cut off from joy, he had ruled the domain of his huge misshapen kind a long time, since God had condemned him in condemning the race of Cain.
>
> —Beowulf, translated by William Alfred, *Medieval Epics*, The Modern Library, New York, 1993

Hollywood has continued the depiction of the sinister and foreboding nature of wetlands and their inhabitants, in the tradition of Grendel, with movies such as the classic *Creature from the Black Lagoon* (1954), a comic-book-turned-cult-movie *Swamp Thing* (1982), and its sequel *Return of the Swamp Thing* (1989). Even Swamp Thing, the man/monster depicted in Figure 1.19, evolved in the 1980s from a feared creature to a protector of wetlands, biodiversity, and the environment. But as long as wetlands remain more difficult to stroll through than a forest and more difficult to cross by boat than a lake, they will remain misunderstood ecosystems to the general public without a continued effort of education.

Wetland Destruction and Conservation

Prior to the mid-1970s, the drainage and destruction of wetlands were accepted practices around the world and were even encouraged by specific government policies. Wetlands were replaced by agricultural fields and by commercial and residential development. Had those trends continued, the resource would be in danger of extinction. Some countries and states such as New Zealand and California and Ohio in the United States have reported 90 percent loss of their wetlands. Only through the combined activities of hunters and anglers, scientists and engineers, and lawyers and conservationists has the case been made for wetlands as a valuable resource whose destruction has serious economic as well as ecological and aesthetic consequences for the nations of the world. This increased level of respect was reflected in activities such as the sale of federal "duck stamps" to waterfowl hunters that began in 1934 in the United States (Fig. 1.20); other countries such as New Zealand have followed suit. Approximately 2.1 million hectares (ha) of wetlands have been purchased or leased as waterfowl habitat by the U.S. duck stamp program alone since 1934. The U.S. government now supports a variety of other wetland protection programs through at least a dozen federal agencies; individual states have also enacted wetland protection laws or have used existing statutes to preserve these valuable resources.

That interest in wetland conservation, which first blossomed in the 1970s in the United States, has now spread around the world. The international Convention on

Figure 1.19 The sinister image of wetlands, especially swamps, is often promoted in popular media such as Hollywood movies and comic books, although the man-turned-plant "Swamp Thing" is a hero as he fights injustice and even toxic pollution. ***(Swamp Thing #9 © DC Comics. All Rights Reserved. Used with Permission.)***

Wetlands, signed in Ramsar, Iran, in 1971, and referred to as the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands around the world. More than 150 countries are participating in the agreement, with over 150 million ha of wetlands designated for inclusion in the Ramsar List of Wetlands

Figure 1.20 Federal Migratory Bird Hunting and Conservation Stamps are more commonly known as "Duck Stamps." They are produced by the U.S. Postal Service for the U.S. Fish & Wildlife Service and are not valid for postage. Originally created in 1934 as the federal licenses required for hunting migratory waterfowl, today income derived from their sale is used to purchase or lease wetlands. *Top:* First Duck Stamp from 1934 (Mallards); *Bottom:* 2005-06 duck stamp (Hooded Merganser).

of International Importance. The Convention's mission is "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (www.ramsar.org, 2006). Many other countries and nongovernmental organizations (NGOs) are now dedicated to preserving wetlands.

Wetland Science and Wetland Scientists

A specialization in the study of wetlands is often termed *wetland science* or *wetland ecology*, and those who carry out such investigations are called *wetland scientists* or *wetland ecologists*. The term *mire ecologist* has also been used. Some have suggested that the study of all wetlands be termed *telmatology* (*telma* being Greek for "bog"), a term originally coined to mean "bog science" (Zobel and Masing, 1987). No matter what the field is called, it is apparent that there are several good reasons for treating wetland ecology as a distinct field of study:

1. Wetlands have unique properties that are not adequately covered by present ecological paradigms and by fields such as limnology, estuarine ecology, and terrestrial ecology.
2. Wetland studies have begun to identify some common properties of seemingly disparate wetland types.
3. Wetland investigations require a multidisciplinary approach or training in several fields not routinely studied or combined in university academic programs.
4. There is a great deal of interest in formulating sound policy for the regulation and management of wetlands. These regulations and management approaches need a strong scientific underpinning integrated as wetland ecology.

A growing body of evidence suggests that the unique characteristics of wetlands—standing water or waterlogged soils, anoxic conditions, and plant and animal adaptations—may provide some common ground for study that is neither terrestrial ecology nor aquatic ecology. Wetlands provide opportunities for testing ''universal'' ecological theories and principles involving succession and energy flow, which were developed for aquatic or terrestrial ecosystems. For example, wetlands provided the setting for the successional theories of Clements (1916) and the energy flow approaches of Lindeman (1942). They also provide an excellent laboratory for the study of principles related to transition zones, ecological interfaces, and ecotones.

Our knowledge of different wetland types such as those discussed in this book is, for the most part, isolated in distinctive literatures and scientific circles. One set of literature deals with coastal wetlands, another with forested wetlands and freshwater marshes, and still another with peatlands. Very few investigators have analyzed the properties and functions common to all wetlands. This is probably one of the most exciting areas for wetland research because there is so much to be learned. Comparisons of wetland types have shown, for example, the importance of hydrologic flow-through for the maintenance and productivity of these ecosystems. The anoxic biochemical processes that are common to all wetlands provide another area for comparative research and pose many questions: What are the roles of different wetland types in local and global biochemical cycles? How do the activities of humans influence these cycles in various wetlands? What are the synergistic effects of hydrology, chemical inputs, and climatic conditions on wetland biological productivity? How can plant and animal adaptations to anoxic stress be compared in various wetland types?

The true wetland ecologist must be an ecological generalist because of the number of sciences that bear on those ecosystems. Knowledge of wetland flora and fauna, which are often uniquely adapted to a substrate that may vary from submerged to dry, is necessary. Emergent wetland plant species support both aquatic animals and terrestrial insects. Because hydrologic conditions are so important in determining the structure and function of the wetland ecosystems, a wetland scientist should be well versed in surface and groundwater hydrology. The shallow-water environment means that chemistry—particularly for water, sediments, soils, and water–sediment interactions—is an important science. Similarly, questions about wetlands as sources,

sinks, or transformers of chemicals require investigators to be versed in many biological and chemical techniques. While the identification of wetland vegetation and animals requires botanical and zoological skills, backgrounds in microbial biochemistry and soil science contribute significantly to the understanding of the anoxic environment. Understanding adaptations of wetland biota to the flooded environment requires both biochemistry and physiology. If wetland scientists are to become more involved in the management of wetlands, some engineering techniques, particularly for wetland hydrologic control or wetland creation, need to be learned.

Wetlands are seldom, if ever, isolated systems. Rather, they interact strongly with adjacent terrestrial and aquatic ecosystems. Hence, a holistic view of these complex landscapes can be achieved only through an understanding of the principles of ecology, especially those that are part of ecosystem and landscape ecology and systems analysis. Finally, if wetland management involves the implementation of wetland policy, then training in the legal and policy-making aspects of wetlands is warranted.

Thousands of scientists and engineers are now studying and managing wetlands. Only a relatively few pioneers, however, investigated these systems in any detail prior to the 1960s. Most of the early scientific studies dealt with classical botanical surveys or investigations of peat structure. Several early scientific studies of peatland hydrology were also produced, particularly in Europe and Russia. Later, investigators such as Chapman, Teal, Sjörs, Gorham, Eugene and H. T. Odum, Weller, Patrick, and their colleagues and students began to use modern ecosystem and biogeochemical approaches in wetland studies (Table 1.1). Several research centers devoted to the study of wetlands have now been established in the United States, including the Sapelo Island Marine Institute in Georgia; the School of Coast and Environment at Louisiana State University; the H. T. Odum Center for Wetlands at the University of Florida; the Duke Wetland Center at Duke University; and the Wilma H. Schiermeier Olentangy River Wetland Research Park (ORWRP) at The Ohio State University. International laboratories such as the Harry Oppenheimer Okavango Research Centre (HOORC) in Botswana, Africa, have been established for the study of specific wetlands or wetland areas. In addition, a professional society now exists, the *Society of Wetland Scientists*, which has among its goals to provide a forum for the exchange of ideas within wetland science and to develop wetland science as a distinct discipline. *The International Association of Ecology* (INTECOL) has sponsored a major international wetland conference every four years somewhere in the world since 1980.

Wetland Managers and Wetland Management

Just as there are wetland scientists who are uncovering the processes that determine wetland functions and values, so too there are those who are involved, by choice or by vocation, in some of the many aspects of wetland management. These individuals, whom we call *wetland managers*, are engaged in activities that range from waterfowl production to wastewater treatment. They must be able to balance the scientific aspects of wetlands with a myriad of legal, institutional, and economic constraints to provide optimum wetland management. The management of wetlands has become

Table 1.1 Some pioneer researchers in wetland ecology and representative citations for their work

Wetland Type and Researcher	Country	Representative Citations
COASTAL MARSHES/MANGROVES		
Valentine J. Chapman	New Zealand	Chapman (1938, 1940)
John Henry Davis	USA	Davis (1940, 1943)
John M. Teal	USA	Teal (1958, 1962); Teal and Teal (1969)
Eugene P. Odum, Howard T. Odum	USA	E. P. Odum (1961); H. T. Odum et al. (1974)
D. S. Ranwell	UK	D. S. Ranwell (1972)
PEATLANDS/FRESHWATER WETLANDS		
C. A. Weber	Germany	Weber (1907)
Herman Kurz	USA	Kurz (1928)
A. P. Dachnowski-Stokes	USA	Dachnowski-Stokes (1935)
R. L. Lindeman	USA	Lindeman (1941, 1942)
Eville Gorham	UK/USA	Gorham (1956, 1961)
Hugo Sjörs	Sweden	Sjörs (1948, 1950)
G. Einar Du Rietz	Sweden	Du Rietz (1949, 1954)
P. D. Moore/D. J. Bellamy	UK	Moore and Bellamy (1974)
S. Kulczynski	Poland	Kulczynski (1949)
Paul R. Errington	USA	Errington (1957)
R. S Clymo	UK	Clymo (1963, 1965)
Milton Weller	USA	Weller (1981)
William H. Patrick	USA	Patrick and Delaune (1972)

increasingly important in many countries because government policy and wetland regulation seek to reverse historic wetland losses in the face of continuing draining or encroachment by agricultural enterprises and urban expansion. The simple act of being able to identify the boundaries of wetlands has become an important skill for a new type of wetland technician in the United States called a *wetland delineator*.

Private organizations such as *Ducks Unlimited, Inc.* and *The Nature Conservancy* have protected wetlands by purchasing thousands of hectares of wetlands throughout North America. Through the *Ramsar Convention* and an agreement jointly signed by the United States and Canada in 1986 called the *North American Waterfowl Management Plan*, wetlands are now being protected primarily for their waterfowl value on an international scale. In 1988, a federally sponsored *National Wetlands Policy Forum* (1988) in the United States raised public and political awareness of wetland loss and recommended a policy of "no net loss" of wetlands. This recommendation has stimulated widespread interest in wetland restoration and creation to replace lost wetlands, and "no net loss" has remained the policy of wetland protection in the United States since the late 1980s.

Subsequently, a National Research Council report in the United States (NRC, 1992) called for the fulfillment of an ambitious goal of gaining 4 million ha of

wetlands by the year 2010, largely through the reconversion of crop and pasture land. Wetland creation for specific functions is an exciting new area of wetland management that needs trained specialists and may eventually stem the tide of loss and lead to an increase in this important resource. Another National Research Council report (NRC, 1995) reviewed the scientific basis for wetland delineation and classification, particularly as it related to the regulation of wetlands in the United States at that time, and yet another NRC (2001) study investigated the effectiveness of the national policy of mitigation of wetland loss in the United States.

The Wetland Scientific Literature

The increasing interest and emphasis on wetland science and management has been demonstrated by a veritable flood of books, reports, scientific studies, and conference proceedings, most in the last two decades of the 20th century and early 21st century. The journal citations in this book are only the tip of the iceberg of the literature on wetlands, much of which has been published since the mid-1980s. Two journals, *Wetlands* and *Wetlands Ecology and Management*, are now published to disseminate scientific and management papers on wetlands, and several other scholarly journals frequently publish papers on wetlands. Dozens of wetland meeting proceedings and journal special issues have been published from conferences on wetlands held throughout the world. Beautifully illustrated popular books and articles with color photographs have been developed on wetlands by Niering (1985), Littlehales and Niering (1991), Mitchell et al. (1992), Kusler et al. (1994), Rezendes and Roy (1996), and Lockwood and Gary (2005) on wetlands in North America; by McComb and Lake (1990) on Australian wetlands; by Mendelsohn and el Obeid (2004) on the Okavango River Delta in Africa; and by Finlayson and Moser (1991) and Dugan (1993) on wetlands of the world.

Government agencies and NGOs around the world have contributed significantly to the wetland literature and to our understanding of wetland functions and values. In the United States, the *U.S. Fish and Wildlife Service* has been involved in the classification and inventory of wetlands and has published a series of community profiles on various regional wetlands. The *U.S. Environmental Protection Agency* (U.S. EPA) has been interested in the impact of human activity on wetlands, and in wetlands as possible systems for the control of water pollution. Along with the *U.S. Army Corps of Engineers*, the U.S. EPA, especially through its Office of Wetlands, Oceans, and Watersheds (OWOW), the U.S. Fish and Wildlife Service, and the *Natural Resources Conservation Service* now are the primary wetland management agencies in the United States.

Wetland management organizations such as the *Association of State Wetland Managers* and the *Society of Wetland Scientists* focus on disseminating information on wetlands, particularly in North America. The *International Union for the Conservation of Nature and Natural Resources* (IUCN) and the *Ramsar Convention*, both based in Switzerland, have developed a series of publications on wetlands of the world. *Wetlands International* is the world's leading nonprofit organization concerned with

the conservation of wetlands and wetland species. It comprises a global network of governmental and nongovernmental experts working on wetlands. Activities are undertaken in more than 120 countries worldwide. The headquarters for its Africa, Europe, Middle East (AEME) branch is located in Wageningen, The Netherlands.

Recommended Readings

Errington, P.L. 1957. *Of Men and Marshes*. The Iowa State University Press, Ames, Iowa.

Finlayson, M., and M. Moser, eds. 1991. *Wetlands. Facts on File*, Oxford, UK 224 pp.

Kusler, J., W. J. Mitsch, and J. S. Larson. 1994. Wetlands. *Scientific American* 270(1): 64–70.

Millenium Ecosystem Assessment. 2005. ''Ecosystems and Human Well-Being: Wetlands and Water Synthesis.'' World Resources Institute, Washington, DC.

Teal, J., and M. Teal. 1969. *Life and Death in the Salt Marsh*. Little, Brown, Boston.