Chapter 1

Wetland History and Science

Wetlands are found in almost all regions of the world. Although many human cultures have lived among and even depended on wetlands for centuries, the modern history of wetlands until the 1970s is fraught with misunderstanding and fear, as described in much of our early Western literature and even in current human media such as science fiction movies. Wetlands have been destroyed at alarming rates throughout the developed and developing worlds. Now, as their many benefits are being recognized, wetland conservation has become the norm. In many parts of the world, wetlands are now revered, protected, and restored; in other parts, they are still being drained for human development.

Because wetlands have properties that are not adequately covered by current terrestrial and aquatic ecology paradigms, wetland science has become 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.

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

Wetlands, Sixth Edition. William J. Mitsch, James G. Gosselink, Christopher J. Anderson, and M. Siobhan Fennessy.

Companion website: www.wiley.com/go/mitsch/wetlands6

of a multitude of chemical, biological, and genetic materials. Although the value of wetlands for fish and wildlife protection has been known for centuries, some of the other benefits have been identified more recently.

Wetlands are sometimes described as **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 mitigating both floods and drought. They have been found to cleanse polluted waters, protect shorelines, and recharge groundwater aquifers.

Wetlands also have been called **nature's supermarkets** because of the extensive food chain and rich biodiversity that they support. They are where a great variety of organisms go to eat or be eaten. 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 before current times 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 early 1800s. In some regions of the world that scale of wetland destruction continues.

Wetlands have become the cause célèbre for conservation-minded people and organizations throughout the world, in part because they support some of the most biodiverse assemblages of plants, animals, and microbes. Scientists, engineers, lawyers, and regulators are now finding it both useful and necessary to become specialists in wetland ecology and wetland management 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 modern cities of the world, such as Chicago and Washington, DC, in the United States; Christchurch, New Zealand; and Paris, France, stand on sites that were once part wetland. Many large airports, such as in Boston, New Orleans, and New York, are situated on former wetlands.

While global generalizations about human cultures and their respect (or not) 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, in part 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**.

Sustainable Cultures in Wetlands

Some of the original wetlander cultures are described here. The Marsh Arabs of southern Iraq (Fig. 1.1) and the Camarguais of southern France's Rhone River Delta (Fig. 1.2) are two examples of ancient cultures that have lived in harmony and sustainably with their wetland environments for centuries. In North America, the Cajuns of Louisiana and several Native Americans tribes have lived in harmony with wetlands for hundreds of years. The Louisiana Cajuns, descendants of the French colonists of Acadia (present-day Nova Scotia, Canada), were forced out of Nova Scotia by the English and moved to the Louisiana delta in the last half of the eighteenth century. Their society and culture flourished within the bayou wetlands (Fig. 1.3). The Chippewa in Wisconsin and Minnesota have harvested and reseeded wild rice (*Zizania aquatica*) along the littoral zone of lakes and streams for centuries (Fig. 1.4). They have a saying: **"Wild rice is like money in the bank."**

Likewise, several Native American tribes lived and even thrived in large-scale wetlands, such as the Florida Everglades. These include the ancient Calusa, a culture that based its economy on estuarine fisheries rather than agriculture. The Calusa disappeared primarily as a result of imported European disease. In the nineteenth century, the Seminoles and especially one of its tribes, the Miccosukee, moved south to the Everglades while being pursued by the U.S. Army during the Seminole

Figure 1.1 The Marsh Arabs of present-day southern Iraq lived for centuries on artificial islands in marshes at the confluence of the Tigris and Euphrates rivers in Mesopotamia. The marshes were mostly drained in the 1990s and are now being restored. (Hassan Janali/Wikimedia Commons)

Figure 1.2 The Camargue region of southern France in the Rhone River Delta is a historically important wetland region in Europe where Camarguais have lived since the Middle Ages. (Uryadnikov Sergey/Adobe Stock)

Figure 1.3 A Cajun lumberjack camp in the Atchafalaya Swamp of coastal Louisiana. (Courtesy of Louisiana Collection, Tulane University Library)

Figure 1.4 "Ricer" poling and "knocking" wild rice (*Zizania aquatica*) into canoes as Anishinaabe (Chippewa, Ojibwe) tribes and others have done for hundreds of years on Rice Lake in Crow Wing County, Minnesota. (With permission of John Overland)

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 (Fig. 1.5). A quote in a Florida newspaper by Miccosukee tribal member Michael Frank is poignant yet hopeful about living sustainably in the Florida Everglades:

Figure 1.5 The Miccosukee Native Americans adapted to life in the Florida Everglades in hammock-style camps. They relied on fishing, hunting, and harvesting of native fruits from the hammocks. (Photo by W. J. Mitsch)

> We were taught to never, ever leave the Everglades. If you leave the Everglades you will lose your culture, you lose your language, you lose your way of life.
>
> **—Michael Frank, as quoted by William E. Gibson, "Pollution Is Killing Everglades, Miccosukee Warn," *South Florida Sun Sentinel*, August 10, 2013**

Literary References to Wetlands

With all of these important cultures vitally depending on wetlands, not to mention the aesthetics of a landscape in which water and land often provide a striking panorama, one might expect wetlands to be more respected 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 Western literature and 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.

Centuries later, Carl Linnaeus, crossing the Lapland peatlands in 1732, 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.

In the eighteenth 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, "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)**

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, Chapter 12 in *The Victorian Age in Literature* (New York, NY: Henry Holt and Company, 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 *Beowulf*, one of the oldest surviving pieces of Old English literature and Germanic epic, 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* (New York, NY: The Modern Library, 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 evolved in the 1980s from a feared creature to a protector of wetlands,

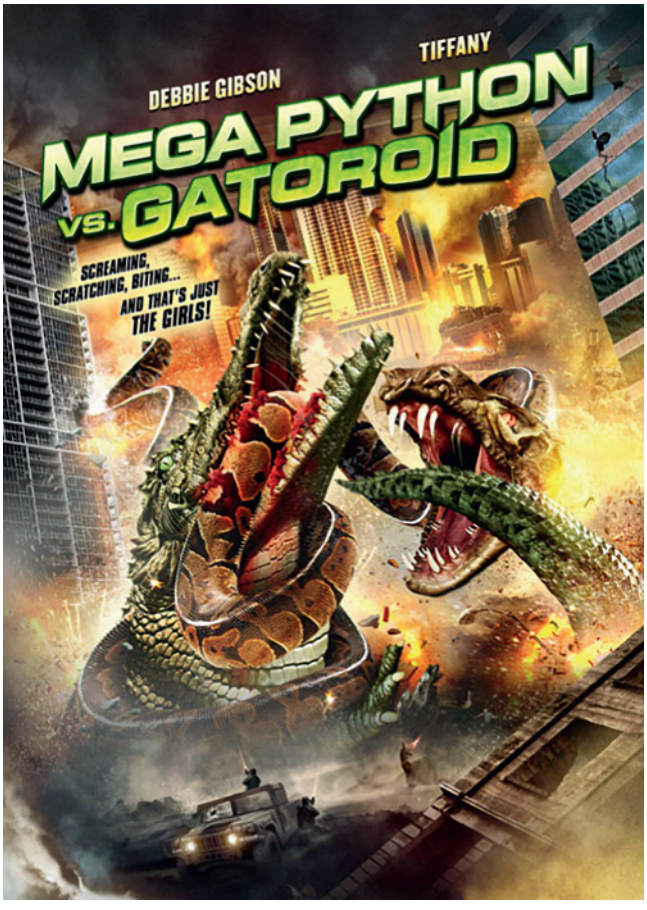

Figure 1.6 The playbill for the *Mega Python vs. Gatoroid* science fiction movie published by The Asylum in 2011 (http://www.theasylum.cc). (With permission of David Latt)

biodiversity, and the environment. A more modern approach to scaring and entertaining the public with megafauna from the swamps is a science fiction movie *Mega Python vs. Gatoroid* (2011; Fig. 1.6), set in the Florida Everglades exaggerates much of the current dynamics about the Florida Everglades including conservation, invasive species, genetically altered organisms, fundraising by conservationists, and conflicts among hunters, conservation agencies, and environmentalists. In some respects, current life in the Everglades imitates art. Big snakes and alligators from wetlands continue to strike fear.

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 by the general public unless a continued effort of education takes place.

Food from Wetlands

Domestic wetlands such as rice paddies feed an estimated half of the world's population (Fig. 1.7). 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. Cranberries are harvested from bogs, and the industry continues to thrive today in North America (Fig. 1.8). 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 production of salt hay. Salt marsh coastlines of Europe are still used for the production of salt.

Wetlands can be important sources 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.

Peat and Building Materials

Russians, Finns, Estonians, and Irish, among other cultures, have mined their peatlands for centuries, using peat as a source of energy in small-scale production (Fig. 1.9) and in large-scale extraction processes (Fig. 1.10). *Sphagnum* peat is now harvested for horticultural purposes

Figure 1.7 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. (Photo by W. J. Mitsch)

Figure 1.8 Cranberry wet harvesting is accomplished 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. (Courtesy of Ocean Spray Cranberries, Inc.)

Figure 1.9 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.

Figure 1.10 Large-scale peat mining in Estonia. (Photo by W. J. Mitsch)

throughout the world. In southwestern New Zealand, for example, surface sphagnum has been harvested since the 1970s for export as a potting medium. Reeds and even the mud from coastal and inland marshes have been used for thatching for roofs in Europe, Iraq, Japan, and China as well as in wall construction, as fence material, and for lamps and other household goods. Coastal mangroves are harvested for timber, food, and tannin in many countries throughout Indo-Malaysia, East Africa, and Central and South America.

Wetlands and Ecotourism

Ecotourism is a modern version of wetland use. Wetlands have been the focus of attempts by several countries to increase tourist flow into their countries. 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 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 (Fig. 1.11). In Senegal, West Africa, there is keen interest in attracting European birder tourists to the mangrove swamps along the Atlantic coastline. For many people, ecotourism in the wetlands is all about the wildlife and especially the birds (Fig. 1.12). It has been reported that bird-watching, or "birding," is a $32 billion per year industry in the United States alone.

The advantage of ecotourism as a management strategy is obvious—it provides income to the country where the wetland is found

Figure 1.11 The vast seasonally flooded Okavango Delta of northern Botswana in southern Africa is a mecca for ecotourism. The wetlands attract tourists, as shown in this illustration, and also wildlife hunting. In addition, the wetlands provide basic sustenance to these communities. (Photo by W. J. Mitsch)

(a) (b)

Figure 1.12 Intense ecotourism interest in the wetlands in Asia is shown by (a) crowds that surround Lake Biwa in Shiga Prefecture, Japan, at a winter 2006 international wetlands forum, and (b) press coverage at the Ramsar Convention held in Changwon, Korea, in 2008. (Photos by W. J. Mitsch)

without requiring or even allowing resource harvest from the area. 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.

Wetland Conservation

Prior to the mid-1970s, 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, wetlands would have been in danger of extinction in some parts of the world decades ago. Some countries and states, such as New Zealand and California and Ohio in the United States, 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. 1.13); other countries, such as New Zealand, have followed

Figure 1.13 Federal Migratory Bird Hunting and Conservation Stamps, also known as Duck Stamps: top first duck stamp with Mallards honoring duck stamps program (Jay N. "Ding" Darling/Wikimedia Commons/Public Domain) and bottom, 2023 duck stamp with Redheads (James Hautman/U.S. Fish and Wildlife Service).

suit. Approximately 2.4 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.

On an international scale, the Convention of Wetlands of International Importance, or the Ramsar Convention, a multinational agreement for the conservation of wetlands, has formally registered as "Wetlands of International Importance" 256 million ha of wetlands in the 172 contracting parties. The Ramsar Convention https://www.ramsar.org/ is the only global international treaty specific to the conservation and wise management of a specific ecosystem. Wetlands International (www.wetlands.org), based in Wageningen, The Netherlands, is the world's leading nonprofit organization concerned with the conservation of wetlands and wetland species.

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 called **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 four good reasons for treating wetland ecology as a distinct field of ecological 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 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.

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.

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. In addition, an international 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 **National Association of Wetland Managers** (NAWM; https://www.nawm.org/), based primarily in the United States, provides a forum for state, federal, and local managers and consultants to meet and discuss wetland management issues. They currently sponsor popular webinars on subjects related to wetlands.

The International Association of Ecology (INTECOL) has sponsored the major international wetland conference every four years somewhere in the world since 1980. Table 1.1 lists the locations around the world where the INTECOL Wetland conference has been held and each meeting's theme, attendance, and resulting publications.

Table 1.1 INTECOL wetland conferences, 1980 to 2021, indicating year, location, theme, approximate attendance, chair/organizer, and resulting publications

Year	Location	Theme	Attendance	Organizer	Key Publication(s)
1980	New Delhi, India		90	B. Gopal	Gopal et al. (1982a, b)
1984	Trebon, Czechoslovakia		210	J. Kvet/ J. Pokorny	Pokorny et al. (1987); Mitsch et al. (1988); Bernard (1998); Whigham et al. (1990, 1993)
1988	Rennes, France	Conservation and Development: The Sustainable Use of Wetland Resources	400	J. C. Lefeuvre	Lefeuvre (1989, 1990); Maltby et al. (1992)
1992	Columbus, United States	Global Wetlands: Old World and New	905	W. J. Mitsch	Mitsch (1993, 1994); Wetzel et al. (1994); Finlayson and van der Valk (1995); Gopal and Mitsch (1995); Jørgensen (1995)

(*Continued*)

Table 1.1 (*Continued*)

Year	Location	Theme	Attendance	Organizer	Key Publication(s)
1996	Perth, Australia	Wetlands for the Future	550	A. J. McComb; J. A. Davis	McComb and Davis (1998); Tanner et al. (1999); Zedler and Rhea (1998)
2000	Quebec City, Canada	Quebec 2000: Wetlands at the Millennium[a]	2160	C. Rubec, B. Belangér, and G. Hood	11 Books/special reports; 6 special journal issues; 8 International Peat Society Proceedings
2004	Utrecht, Netherlands		787	J. T. A. Verhoeven	Vymazal (2005); Bobbink et al. (2006); Junk (2006); van Diggelen et al. (2006); Verhoeven et al. (2006); Davidson and Finlayson (2007); Whitehouse and Bunting (2008)
2008	Cuiaba, Brazil	Big Wetlands, Big Concerns	700	P. Teixeira de Sousa Jr.; C. Nunes da Cunha	Vymazal (2011); Junk (2013)
2012	Orlando, United States	Wetlands in a Complex World[b]	1240	R. Best/ K. R. Reddy	
2016	Changshu, China	10th INTECOL International Wetlands Conference	1700	Shuqing An, Cheng Li, and Jianguo Fan	An and Verhoeven (2019)
2021	Christchurch, New Zealand	11th INTECOL International Wetlands Conference	470 (virtual and in person)	Philippe Gerbeaux and Shona Myers	No publications yet

[a] INTECOL met with three additional societies in 2000: International Peat Society, International Mire Conservation Group, and Society of Wetland Scientists.
[b] INTECOL met with Society of Wetland Scientists in 2012.

The increasing interest and emphasis on wetland science and management has been demonstrated by a veritable flood of books, reports, scientific journal articles, and conference proceedings, most in the last two decades of the twentieth century and the first two decades of the twenty-first century. From 1991 to 2021, the annual number of wetland research journal articles published increased by 11-fold. Two journals specific to wetlands—*Wetlands* and *Wetlands Ecology and Management*—are now published to disseminate scientific and management papers on wetlands.

Recommended Readings

Beautifully illustrated popular books and articles, many with color photographs, were developed on wetlands by many authors in years past. Here are some of our timeless favorites.

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