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Paul A. Keddy
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1 Wetlands: An Introduction

CHAPTER CONTENTS

All life contains water. From distant space, Earth appears as a mosaic of blue and green, blue for water, green for plants. This book is about the ecological communities that occur where green meets blue: wetlands. Wetlands are intimately associated with water. They are one of the most productive habitats on Earth, and they support many kinds of life (Figure 1.1). This book explores the general principles that control the distribution and composition of wetlands around the world.

Wetlands have always influenced humans. Early civilizations first arose along the edges of rivers in the fertile soils of floodplains. Wetlands continue to produce many benefits for humans – along with fertile soils for agriculture, they provide food such as fish as well as many other kinds of wild animals. Additionally, they have other vital roles that are less obvious – they produce oxygen, store carbon and process nitrogen. Of course, wetlands have also been a cause of human suffering, such as providing habitat for mosquitoes that carry malaria. And, for thousands of years, human cities in low areas have flooded during periods of high water. Philosophers and theologians may enquire how it is that one system can be both life-giving and death-dealing. Our more confined task as scientists is

- to explore the basic patterns that occur in wetlands,
- to uncover the causes of these patterns, and
- to guide society in wise coexistence with wetlands.

I intend to take you through these three steps in this book. Along the way, we will encounter not only hard science, but some entertaining natural history – fish that breathe air, mosses that drown trees, plants that eat insects, and frogs that climb trees. We shall also meet the

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world's largest wetlands, wetlands that perch on the tops of mountains, wetlands that burn and, of course, wetlands that flood.

1.1 Definitions and Distribution

Wetlands form at the interface of terrestrial and aquatic ecosystems and have features of both. While wetlands may be highly variable in appearance and species composition, flooding is a shared characteristic that affects the soil processes and the biota.

1.1.1 What Is a Wetland?

A wetland is an ecosystem that arises when inundation by water produces soils dominated by anaerobic processes, which, in turn, forces the biota, particularly rooted plants, to adapt to flooding.

This broad definition includes everything from tropical mangrove swamps to subarctic peatlands. This single sentence of definition has a complex structure: there is a cause (inundation by water), a proximate effect (reduction of oxygen levels in the soil) and a secondary effect (the biota must tolerate both the direct effects of flooding and the secondary effects of low oxygen levels). It is not the only definition, and maybe not even the best, but it shall get us started. Since many other biologists and lawyers and agencies and organizations have attempted to define wetlands, we shall start with this simple definition. We shall explore other definitions later in this chapter. We shall also look more closely at how flooding reduces oxygen levels and how wetland organisms cope with this challenge.

Since wetlands require water, the obvious place to begin is the distribution of water on Earth. A majority of the Earth's available water is in the oceans. Only a small fraction of the Earth's water is present as fresh water. The fresh water is created when heat from the sun evaporates water vapour from the oceans. Some of this water returns to land as precipitation. As it drains back into the ocean through rivers and lakes, wetlands are created. Some wetlands also form along the edges of oceans; these tend to be mangrove swamps in equatorial regions and salt marshes at higher latitudes. A majority of wetlands are, however, freshwater ecosystems. Some people regard the distinction between freshwater and saltwater wetlands as critical, and you will often run into many documents that refer to "interior wetlands" and "coastal wetlands." Yes, salinity is important in determining which kinds of plants and animals occur in a wetland, but in this book, we shall do our best to think about wetlands as one group of ecosystems.

1.1.2 Where Do Wetlands Occur?

Figure 1.2 shows the approximate global distribution of global wetlands. Such a map has many limitations. It is difficult to map wetlands at the global scale for at least three reasons. First, wetlands are frequently a relatively small proportion of the landscape. Second, they are often distributed in small patches or strips, and therefore cannot be mapped at a scale suitable for reproducing in a textbook. Third, they are very variable, and one area of wetland may have several types of wetlands. To offer another view, Table 1.1 lists the largest wetland areas in the world. These set an important priority list for research and conservation.

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Table 1.1 The world's largest wetlands (areas rounded to the nearest 1000 km^2)

Rank	Continent	Wetland	Description	Area (km^2)
1	Eurasia	West Siberian Lowland	Bogs, mires, fens	2 745 000
2	South America	Amazon River basin	Floodplain forest and savanna, marshes, mangrove	1 738 000
3	North America	Hudson Bay Lowland	Bogs, fens, swamps, marshes	374 000
4	Africa	Congo River basin	Swamps, riverine forest, wet prairie	189 000
5	North America	Mackenzie River basin	Bogs, fens, swamps, marshes	166 000
6	South America	Pantanal	Savannas, grasslands, riverine forest	138 000
7	North America	Mississippi River basin	Bottomland hardwood forest, swamps, marshes	108 000
8	Africa	Lake Chad basin	Grass and shrub savanna, marshes	106 000
9	Africa	River Nile basin	Swamps, marshes	92 000
10	North America	Prairie potholes	Marshes, meadows	63 000
11	South America	Magellanic moorland	Bogs	44 000

Source: From Fraser and Keddy (2005).

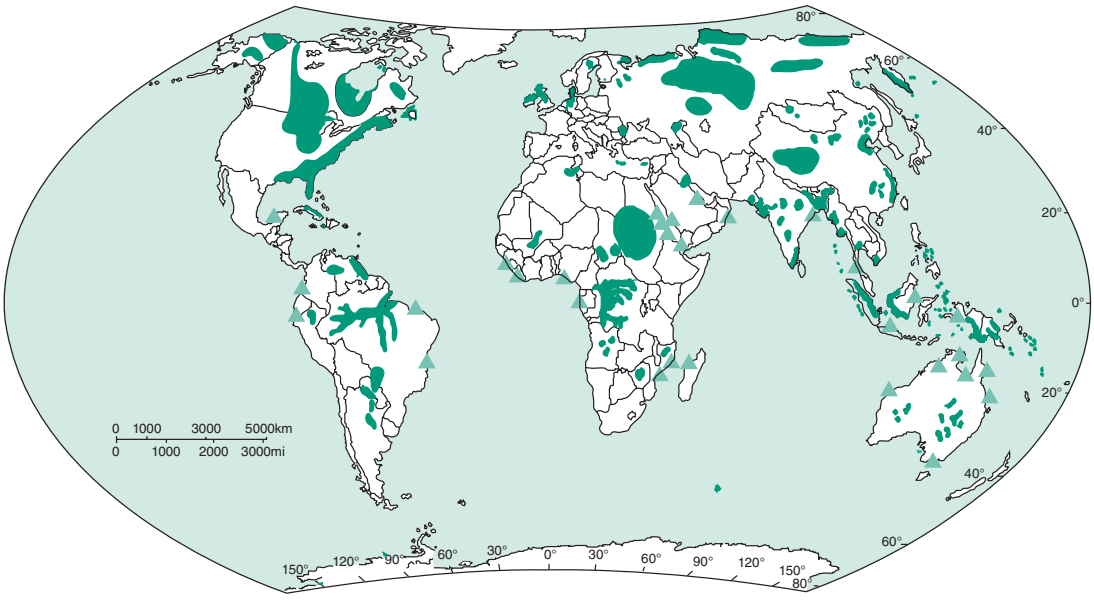

Figure 1.2 The major wetland areas on Earth. Mangrove swamps are shown as triangles. (Compiled from Dugan 1993 and Groombridge 1992.) Given the global distribution, it is not surprising to find that many different wetland classification schemes have been developed. They vary, for example, by geographic region, the intended use of the classification results, and the scale at which classification is undertaken. We will start with a simple classification system that distinguishes six wetland types largely on the basis of location and hydrology. After learning more about the environmental factors that control the development of wetlands and their communities, we will return to wetland definition and classification (Section 1.9).

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1.2 Types of Wetlands

Now that we have a definition, and some idea of where wetlands occur, the next step is to sort them into similar types. Each type can be visualized as a particular set of plant and animal associations that recur. This recurrence probably means that the same causal factors are at work. In trying to name the kinds of wetlands, we run into a problem at the very start: the terminology for describing wetlands varies both among human societies and even among scientists. Thus, one finds an abundance of words used to describe wetlands – bog, bayou, carr, fen, flark, hochmoor, lagg, marsh, mire, muskeg, swamp, pocosin, pothole, quagmire, savanna, slough, swale, turlough, yazoo – in the English language alone. Many of these words can be traced back centuries to Old Norse, Old Teutonic or Gaelic origins (Gorham 1953). Now add in other world languages, and the problem is compounded.

1.2.1 The Six Basic Types of Wetlands

To keep the terminology simple, we will begin with four types of wetlands, and then add two to extend the list to six. One of the simplest classification systems recognizes only four types: swamps, marshes, fens and bogs.

Swamp

A wetland that is dominated by trees that are rooted in hydric (water-saturated) soils, but not in peat (Figure 1.3). Examples would include the tropical mangrove swamps of India, bottomland forests in floodplains of the Mississippi River valley in the United States, and *Pterocarpus* swamps in Central America. Swamps may be further subdivided based upon the size of the woody plants, with shrub swamps being treated as different from treed swamps.

Marsh

A wetland that is dominated by herbaceous plants that are usually emergent through water and rooted in hydric soils, but not in peat (Figure 1.4). Examples would include sedge (*Carex lacustris*) marshes around the Great Lakes and reed (*Phragmites australis*) beds around the Baltic Sea. Marshes often have dense reserves of buried seeds to regenerate when low-water periods occur.

Bog

A wetland dominated by *Sphagnum* moss, sedges, ericaceous shrubs, or evergreen trees rooted in deep peat with a pH less than 5 (Figure 1.5). Examples would include the blanket bogs that carpet mountainsides in northern Europe, and the vast peatland of the West Siberian Lowland in central Russia. Large areas of northern North America and southern South America also have bogs. Peatlands also occur in tropical areas and may have rainforest vegetation.

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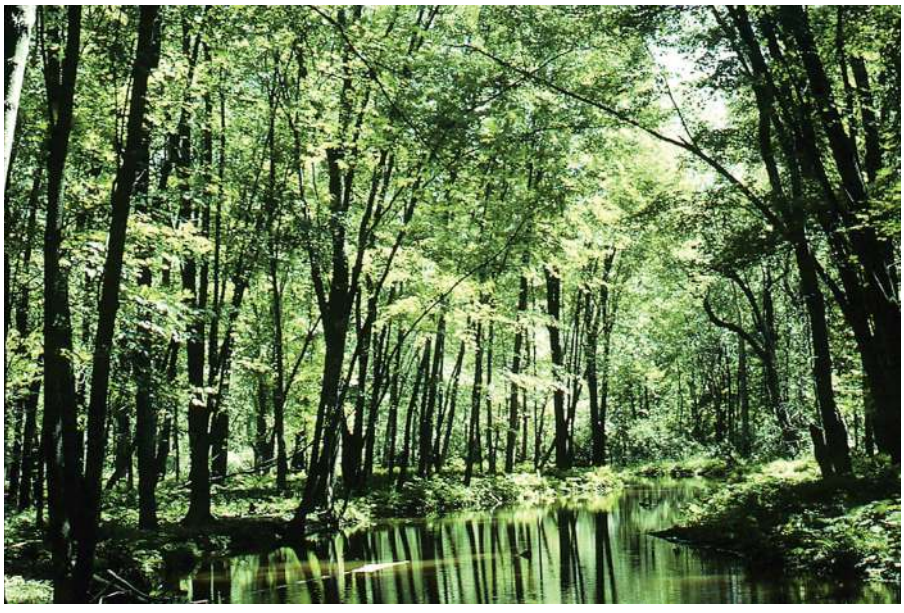

(*b*)

Figure 1.3 Swamps. (*a*) Floodplain swamp (Ottawa River, Canada). (*b*) Mangrove swamp (Caroni wetland, Trinidad).

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(*a*)

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Figure 1.4 Marshes. (*a*) Riverine marsh (Ottawa River, Canada; courtesy B. Shipley). (*b*) Salt marsh (Petpeswick Inlet, Canada).

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(*a*)

(*b*)

Figure 1.5 Bogs. (*a*) Lowland continental bog (Algonquin Park, Canada). (*b*) Upland coastal bog (Cape Breton Island, Canada).

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Fen

A wetland that is usually dominated by sedges and grasses rooted in shallow peat, often with considerable groundwater movement, and with pH greater than 6 (Figure 1.6). Many occur on calcareous rocks, and most have brown mosses, in genera including *Scorpidium* or *Drepanocladus*. Fens are often mixed with bogs and occur within the extensive peatlands of northern North America and Europe, as well as in many smaller seepage areas throughout the temperate zone, and in high-altitude valleys.

Other wetland types could be added to these four. Two important ones follow.

Wet Meadow

A wetland dominated by herbaceous plants rooted in occasionally flooded soils (Figure 1.7). These depend upon natural water level fluctuations, particularly along lakes and rivers. Temporary flooding drowns the terrestrial plants and trees. Subsequent dry periods then allow emergence of many species from buried seeds, producing diverse plant communities in moist soils. Examples would include wet prairies along river floodplains, and meadow marshes on the shorelines of large lakes. Since these wetlands are produced by periodic flooding, they are easily overlooked if visited during a dry period.

Aquatic

A wetland community dominated by mostly aquatic plants growing in and covered by at least 25 cm of water (Figure 1.8). Examples include the littoral zones of lakes, bays in rivers, and the more permanently flooded areas of prairie potholes. Large areas may be covered by floating-leaved plants such as water lilies.

Any attempt to sort the diversity of nature into only six categories will have its limitations. The Everglades, for example, have a peat substrate, moving water and many sedges. So, should we consider the area a vast fen, or a marsh, or a wet prairie, or a mixture of several of these, or something completely different? Each option has its limitations. Rather than worry further about how to name wetlands, we should probably admit that wetlands show great variation, and agree not to get stalled or diverted by too many debates over terminology. Perhaps we should let Cowardin and Golet (1995) have the last words: "no single system can accurately portray the diversity of wetland conditions world-wide. Some important ecological information inevitably will be lost through classification."

1.2.2 Three Other Views on Wetland Classification

The system I present above has the advantage of simplicity and generality. There are four wetland types, six if you wish to expand it slightly. (I prefer the six categories, because otherwise wet meadows and aquatic communities tend to be overlooked. Moreover, the organisms in these habitats have distinctive features.) You should be aware that there are far more elaborate systems, and that these vary around the world. Each wetland classification system tries to

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(*a*)

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Figure 1.6 Fens. (*a*) Patterned fen (northern Canada; courtesy C. Rubec). (*b*) Shoreline fen (Lake Ontario, Canada).

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(*a*)

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Figure 1.7 Wet meadows. (*a*) Sand spit (Long Point, Lake Ontario, Canada; courtesy A. Reznicek). (*b*) Gravel lakeshore (Tusket River, Canada; courtesy A. Payne).

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