FRESHWATER WETLAND RESOURCES AND BIOLOGY

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Contents

Summary

The term “wetlands” means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. They are located at the ecotones between dry terrestrial ecosystems and permanently wet aquatic ecosystems. As such, they have an intermediate hydrology, a biochemical role as source, sink or transformer of chemicals, and generally high productivity if they are open to hydrologic and chemical fluxes. Wetlands have an almost unlimited capacity for accumulation of organic matter, and hence act as a major sink for carbon. However, they also comprise a large source of methane emissions, accounting for one-fifth of the total fluxes to the atmosphere at present. They therefore play a significant role in the global greenhouse gas balance. Wetlands have many positive ecological and environmental functions which society values. In order to maximize these values there will need to be a balance struck between wetland conservation, sustainable utilization and economic development.

1. Introduction

Wetlands comprise about 6% the world’s surface with about a quarter of the total consisting of saline coastal wetlands and the remainder being inland freshwater wetland. In the past wetlands were considered to be wasteland and worthless, and change and transformation have been the predominant themes when considering them. In recent decades, however, wetlands have assumed a new attraction and value. On the one hand, they are still being reduced in size as modern draining techniques make them even more attractive as potential agricultural land, and their flatness, coastal location and perceived worthlessness make them obvious locations for large plants, harbors and waste disposal. Wetlands in this respect are truly “a threatened landscape.” On the other hand, they have become more valued as their hydrological-physical, chemical, biological and socioeconomic benefits are acknowledged. Their value for fish and wildlife protection has been known for several decades but wetlands are increasingly perceived as an environment where air, water and land, and their fauna and flora, meet in an attractive and delicate way, and this has caught the scientific and popular imagination. Demands for their conservation and non-use are now widespread.

Wetlands are broadly defined as habitats where the water table lies above or close to the surface of the rock substrate for a significant part of the year and which, under normal circumstances, support a prevalence of vegetation typically adapted for life in saturated soil conditions. Freshwater wetlands can be further subdivided into those where decomposition rates are low and there is an accumulation of organic matter (peat) to form bogs and fens or those where organic matter accumulation is negligible and the rooting medium is mainly mineral (marshes and swamps). Marshes have been described as having summer water levels close to but not above ground levels, in which the soil is inorganic, while fens are corresponding vegetation types where the soil is organic (peat) and largely neutral in pH. In swamps the vegetation is different because water levels are normally above the soil surface, while in bogs the vegetation is influenced by the fact that the peat substrate is very acid.

The most characteristic vegetation of fen, marsh and swamp consists of emergent aquatic species, and although the wetland plant communities of the tropics are floristically different from those of the temperate zone, differences are not so great as between terrestrial communities. These wetlands can cover very extensive areas, and probably one of the largest is the “Sudd” of southern Sudan, which occupies 150 000 km^2 during the wet season. Bogs have a vegetation that is markedly different to the other wetlands, because in general the plants have to tolerate relatively cool, wet conditions and a rooting medium which is highly acidic and extremely low in available nutrients. As a consequence, the primary productivity of bogs is much lower than the emergent vegetation of fen, marsh, and swamp. The latter are normally at the top of lists of primary productivity of natural communities.

2. Wetland Types

The term “wetland” is a relatively new one to describe the landscape that has been known under different names in the past. The history of the use of these terms has often revealed a clear regional or at least continental origin. Although the lack of standardization of terms is confusing, each of these terms have a specific meaning to the initiated, and many are still used by both scientists and laypersons. Table 1 illustrates the confusion in terminology that occurs because of different uses of terms in North America and Europe. In North American terminology, non-forested inland wetlands are often casually classified either as peat-forming, low-nutrient acid bogs or as marshes. On the other hand, the much older European terminology is much richer and distinguishes at least four different kinds of wetlands, from mineral-rich reed beds, called swamps, to wet grassland marshes, to fens, and finally to bogs. The European classification is based on the amount of surface water and nutrient inflow (rheotrophy), type of vegetation, pH, and peat-building characteristics. Of course these physical and biotic characteristics can, and do, grade continuously from one of these wetland types to the next, so that any classification must be to some extent arbitrary. It is also important to appreciate that the same term may refer to different systems in different regions. For example, a European swamp is dominated by reeds but in North America the term "swamp" is almost always used to describe a forested wetland. Whatever the name given to them, the distinguishing feature of wetlands is the interplay between land and water, because they are situated at the junction between dry-land terrestrial ecosystems and permanently wet aquatic ecosystems. This transition zone is known as an ecotone.

<table>
<tr><td>North American terminology</td><td colspan="3">← Marsh or fen →</td><td>← Bog →</td></tr>
<tr><td>European terminology</td><td>← Swamp →</td><td>← Marsh →</td><td>← Fen →</td><td>← Bog →</td></tr>
<tr><td>Characteristics</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Vegetation</td><td>← Reeds →</td><td colspan="2">← Grasses and sedges →</td><td>← Mosses →</td></tr>
<tr><td>Hydrology</td><td colspan="3">← Rheotrophic →</td><td>← Ombrotrophic</td></tr>
<tr><td>Soil</td><td colspan="2">← Mineral →</td><td colspan="2">← Peat →</td></tr>
<tr><td>pH</td><td colspan="2">← Roughly neutral →</td><td colspan="2">← Acid →</td></tr>
<tr><td>Trophic state</td><td>← Eutrophic →</td><td colspan="2">← Mesotrophic →</td><td>← Oligotrophic →</td></tr>
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Table 1. Comparison of terms used to describe freshwater wetlands (adapted from Mitsch and Gosselink, 1993)

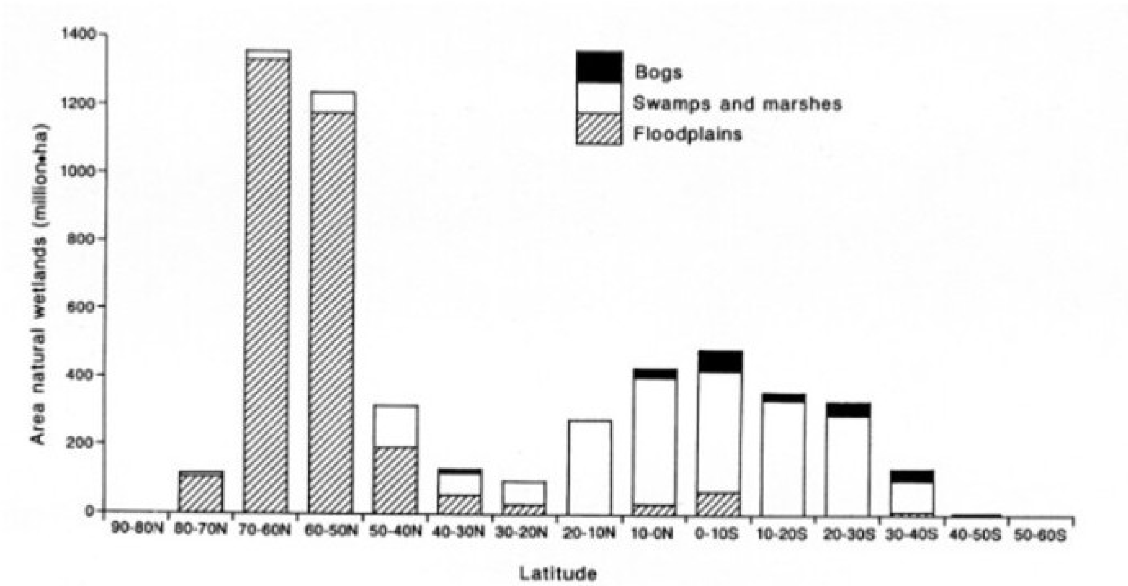

Figure 1. Global distribution of natural wetlands along 10° bands of latitude (adapted from Adger and Brown, 1994)

There are a number of distinguishing features of wetland ecosystem components, which have a major impact on the ecosystem function. Their soils are formed and conditioned by standing water or waterlogging and are adapted to anoxic biochemical processes. Their vegetation is adapted to wet conditions, because it is water-covered for at least part of the growing season and is thus deficient in oxygen. It also decomposes slowly and contributes to the process of wetland formation by either trapping silt or forming actual soil from detritus, that is, peat. In addition, the fauna has adapted to dwelling in anaerobic conditions in the water (fish) or moves seasonally into the wetland (birds).

Globally, although wetlands may vary in detail, there are many similarities between their physiological and ecological characteristics. However, because of their scattered distribution and difficulties in the precise definition of wetland, we have rather unreliable information on their global coverage. Figure 1 shows the broad geographic distribution of natural wetlands. The largest wetland areas are the cold wet boreal regions between latitude 50° N and 70° N but the tropical and subtropical regions, maybe surprisingly, account for 56% of the total.

3. Wetland Vegetation

Wetland areas are commonly dominated by a single species which restricts the establishment and growth of other plants. For example, the papyrus swamps of East and Central Africa are almost monospecific communities of *Cyperus papyrus* while in temperate regions extensive stands of *Phragmites australis* or *Typha latifolia* dominate many wetland areas and these species also extend into much warmer climates. However, some wetlands are relatively species rich, especially fens, with more than 50 species per 100 m^2. These species-rich communities are normally less productive than wetlands with low species diversity.

The most important genera of emergent macrophytes in natural communities are *Typha*, *Phragmites*, and *Cyperus*, with others like *Miscanthidium*, *Cladium*, and *Echinochloa* becoming more important locally. Probably the most important agricultural crop on a global scale is the domesticated tropical reedswamp grass, rice (*Oryza sativa*). It feeds more than half of the world's population and it is usually grown in paddy fields, which are flooded for a large part of the growing period. There are at least 20 species of *Oryza*, but the domesticated *O. sativa* may have been derived from annuals, which resemble the present-day weed species found in ditches and ponds adjacent to rice fields.

In general, the vegetation of wetlands appears to have a worldwide similarity which is more closely determined by the plentiful supply of water and a hostile environment for the roots than the climatic conditions. The hostile root environment is due to a restricted oxygen supply and the presence of nutrients in a reduced form. This is because when oxygen supply is limited, most soil microorganisms make use of electron acceptors other than oxygen for respiration, and this results in the conversion of many compounds into a state of chemical reduction which is manifested by a reduction in soil redox potential. Also, wetland environments are frequently subject to perturbations, the most important of which are the seasonal changes in water levels which in extreme cases, such as in the central Amazon region, can be as much as 10 m during one year. On the other hand, the ability of plants to survive in a wetland site confers a number of advantages, which include reduced competition from less flood-tolerant species, reduced grazing by large herbivores, and in cooler climates the over-winter protection of roots and rhizomes by burial in anaerobic mud. It is apparent that plants growing in this environment have developed a range of morphological, anatomical, and physiological adaptations which aid their survival.

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Biographical Sketch

Professor Michael B. Jones graduated from the University of Lancaster with a first degree in Biological Sciences in 1968 and a Ph.D. in 1971. He lectured in the Botany Department of Makerere University, Uganda from 1971 to 1973 and then worked at the Grassland Research Institute, Hurley, UK until 1978, when he moved to Trinity College, University of Dublin. Professor Jones now holds the 1711 University Chair of Botany and is currently Dean of the Science Faculty in Trinity College. His research interests are in climate–plant interactions, particularly the effects of climate on photosynthesis, growth, and productivity. He coordinated the EU funded INCO-DC project entitled ”The sustained agricultural development of tropical wetlands in south America and east Africa” which ran from 1993 to 1996’.