FLORA AND VEGETATION OF FRESHWATER WETLANDS IN THE COASTAL ZONE OF THE GULF OF MEXICO

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INTRODUCTION

Freshwater wetlands are closely related to the estuarine and marine systems of the Gulf of Mexico. It is crucial to understand, in a broader context, their characteristics, interrelations and importance as part of the coastal wetlands. For this reason, other chapters included in this section on the ecosystems of the Gulf of Mexico are recommended reading.

The Gulf of Mexico is the ninth largest body of water in the world. It covers an area of 1,314,000 m^2 and contains 33 riparian systems and 207 estuaries (Giattina and Altsman 1999). The Gulf of Mexico contains two of the most extensive floodplains on the continent: the Mississippi and Grijalva-Usumacinta deltas. The former contains 40% of the most important coastal salt marshes and freshwater wetlands in the United States of America (Day 1988). The latter contributes 30% of Mexico's total flow of freshwater (Chavez *et al.* 1988). The annual water discharge of the Mississippi River is estimated at 577 km^3 (the second largest volume of flow of any river in the world) and the delta forms a plume of freshwater that extends more than 100 km over the continental shelf off the coasts of Louisiana and Texas (Birkett and Rapport 1999), greatly affecting the coastal waters due to the terrigenous material, dissolved nutrients and organic material it contains (Darnell and Defenbaugh 1990). Corresponding data concerning wetlands and deltas that discharge their water and sediment on the Mexican Gulf Coast is unknown, particularly in the case of the Grijalva and Usumacinta rivers.

In general, the importance of wetlands in relation to the diversity of flora and fauna and the extinction of certain species is recognized. They are also important for the infinite number of resources and services the floodplains in coastal regions provide the countries surrounding the Gulf: USA (Texas, Louisiana, Mississippi, Alabama and Florida), Mexico (Tamaulipas, Veracruz, Tabasco, Campeche, Yucatan and part of Quintana Roo) and Cuba (Cabo San Antonio, east coast). These floodplains are used for fishing, the exploitation of forest resources and animals, irrigation for agriculture, navigation and recreation. It is important to point out that exploitation of oil and gas reserves, as well as other nonrenewable resources in the region, have lead to the modification and destruction of wetland habitats in the Gulf of Mexico.

IMPORTANT WETLANDS OF THE GULF OF MEXICO

The following subdivision of wetlands into six areas is taken from the classification of Moreno-Casasola (1999):

1. Mississippi Delta
2. Everglades
3. Central Gulf of Mexico
4. Usumacinta Delta
5. Yucatán Peninsula
6. Cuba

Moreno-Casasola (1999) offers a comparative table of the main natural characteristics of each region (geomorphological, hydrological and climatic) that must be taken into consideration when attempting to compare among wetlands in an ecosystem of this size. These characteristics are reflected largely in the distribution and composition of the flora. For this reason, in general, preliminary terms, we can find similarities between the wetlands of Mississippi and those of Usumacinta, and the central Gulf region in the states of Tamaulipas and Veracruz. The Florida wetlands, and in particular the Everglades, are different from all the others in terms of their vegetation, although some flooded communities (such as the mangrove wetlands, among others) situated close to the coast, are similar to those on the Yucatan Peninsula. The wetlands of the Yucatan Peninsula (mainly on its coastal fringes) and the island of Cuba are more similar to the Caribbean and have more in common with the Antilles than with the Gulf of Mexico.

According to Day (1988) one important difference between the Mississippi Delta and the Usumacinta Delta is the effect of long-term human activity on the Mississippi floodplain, especially due to unplanned human developments. This has resulted in, among other things, the accumulation of large quantities of nutrients (eutrophication) cropland runoff, which have severely degraded the natural systems. Meanwhile, the great floodable regions of Tabasco and Campeche still have time (although the current situation needs to be reviewed) to draw up plans for the conservation and management of natural resources.

Eutrophication is a process characterized by the accumulation of nutrients reflected in algal blooms and the death of native fish due to low concentrations of dissolved oxygen. In many cases these fish are replaced by others, which are able to withstand urban and agricultural pollution (Day 1988). Other effects of the construction of a 15,000 km network of canals in Louisiana is the intrusion of seawater into freshwater areas causing the disappearance of freshwater flora and fauna, as well as the modification of the salt marshes through the accumulation of dredge material and silt). These manmade canals are used to facilitate drainage and control flooding, navigation and, above all, the activities of the oil industry (Day 1988).

CLASSIFICATION OF WETLANDS & RELATED PROBLEMS

In general, the different classifications and definitions of the world's diverse wetlands become more complex when attempts are made to use them for naming and grouping together the bodies of water of a specific region or country. Evidently, changes at different latitudes caused by the different origins and characteristics of each wetland, plus limited information about them, preclude any classification scheme from being universal. However, as a starting point, five wetland systems can be identified, adopted from the Ramsar Convention (Niering 1985):

I. Coastal (with oceanic influence)
- 1. marine
- 2. estuarine

II. Freshwater
- 3. lacustrine
- 4. riparian
- 5. palustrine

The first category (coastal) includes salt marshes, mangroves and communities of marine grasses. With the second group (with freshwater influence, which is what concerns us in this present chapter), it is confusing and complicated to try to differentiate and group together a large number of aquatic environments due to the enormous range of habitats and ecotones that exist in the continuum of wetlands in the Gulf of Mexico. However, in general, they can be characterized as followings: lacustrine includes wetlands in the form of lakes and ponds; riparian includes rivers and streams and their associated floodplains; and palustrine which, in the United States and Canada, are divided into three categories marshes (emergent herbaceous plants), swamps (great floodplains dominated by woody plants) and bogs (areas formed by glaciers, soil is acidic and poor in nutrients, and vegetated by evergreen trees and shrubs with *Sphagnum*). A third group would include manmade bodies of water. The Ramsar classification is seriously limited in the inland wetlands category particularly with regard to its definition of freshwater wetlands, as Semeniuk and Semeniuk (1997) have pointed out, mainly because, as a system, it employs a combination of several imprecise definitions, rendering its application inconsistent.

FLORA AS A BIOINDICATOR OF COASTAL WETLANDS

Some classifications, particularly when attempting to establish a wetland hierarchy, use physiognomical characteristics of the vegetation. Thus, floristic composition helps distinguis different wetlands. However, great care must be taken when interpreting the presence or absence of certain species, especially if we lack the appropriate knowledge of the flora and vegetation of the place being studied. The well-known plasticity of aquatic plants constitutes a fundamental challenge to ecologists and other professionals who manage and conserve wetlands. This brings to mind strictly hydrophytic species (vascular aquatic plants) that are restricted to the aquatic environment, and how subjective the process of classifying life forms can be, not only in different wetlands but also at their edges and in their ecotones.

Some authors, such as Hofstetter (1988) emphasize the significance of the impact of human activity on the morphological and physiological responsiveness of some hydrophytes that adapt to the modification of their habitat. They tend to respond in one or more of the following ways:

1. phenological changes;
2. reduction in the concentration of secondary compounds related to herbivore defenses;
3. reduction in disease resistance; and
4. morphological changes in their general appearance, vigor, size, and presence of dead parts.

The recent study carried out by Aznar *et al.* (2003) details the effects that pressures of human society have had on aquatic vegetation and landscapes, and in particular on the wetlands of the Mediterranean. This study highlights the significance of the integrating role that hydrophyte communities play in a wetland, the presence species that depend on disturbance, such as *Ludwigia peploides* (a cosmopolitan invasive hydropyhte that replaces numerous native species) and, in general, the replacement of specialized aquatic plants by generalist exotic species. The growing presence of canals and dikes for water management encourages the dispersion and establishment of weeds and invasive plants in general. One important hypothesis put forward by the study suggests that measurements of the spatial density of hydrophytic communities related to a hydrological network provide specific landscape indicators and permit an estimation of the impact of anthropogenic pressures on biodiversity (Aznar *et al.* 2003).

One example documents the impact of human development projects on the wetlands of the Gulf of Mexico and, more specifically, the floodplains of the Mississippi River in Louisiana. This study showed that the hydrological changes resulting from construction of levees, dikes, short cuts to avoid river meanders and canals, led to erratic hydrology that increased rather than decreased flooding (Day 1988).

The analysis by Higer and Kolipinski (1988) of a marsh area in the Everglades of Florida demonstrates that the reduction in herbaceous aquatic vegetation and its substitution with semi-aquatic or terrestrial plants, or monotypic populations of sedges is due to reduction in the length of time the area was flooded, particularly between 1940-1951. Following the launch of a large water control project, loss of soil as well as its compaction and oxidization was observed, which, together with frequent fires, accelerated the lowering of water levels and resulted in unsuitable conditions for the development of native aquatic vegetation.

Bearing in mind the above considerations, it is essential that research is carried out that compares the vegetation structure and associations that can be distinguished in wetland mosaics. Studies should focus on floristic composition and forms, diversity, seasonality, distribution and zonation of dominant species. This focus on units of vegetation and their floristic composition is the basis for attempts to describe the freshwater wetlands of the costal region of the Gulf of Mexico.

However, there are wetlands with no or only a small amount of vegetation. These wetland types are frequently found along the shallow shores of large bodies of water. Some factors that limit the presence of vegetation are constant surf activity, extreme fluctuations in water levels, and the existence of sediments with either a poor nutrient content or high concentrations of salt. An example of this is a type of intermittent wetland without vegetation or with just a few isolated plant elements called *blanquizales*, floodplains during the rainy season, in the coastal zones of Campeche. The submerged forms disappear due to the increase in suspended particles and the permanent turbulence in the water column.

The following paragraphs comment on some of the species that can serve as bioindicators of different wetlands or certain ecological conditions.

VEGETATION OF FRESHWATER WETLANDS

The wetlands and aquatic environments considered in this chapter are those that permit the development of plants that have adapted to living in flooded conditions. These include strict hydrophytes (submerged, emergent and floating forms) to subaquatic and tolerant forms, with herbaceous and woody examples in all cases (Fig. 16.1).

As was previously mentioned, there is no universally accepted classification of wetlands and, in any case, the one that exists is not applicable to the vast majority of the freshwater ecosystems of Mexico's coastal plains, largely due to the lack of equivalent units. The problem might be thought to be one of nomenclature, but in fact it is much deeper than that, partly due to the shortage of ecological studies on the structure of vegetation covering a great diversity of wetlands in the central and southern regions of the Gulf of Mexico. Another element, that further complicates the question of wetland definition and classification, is the instability of many aquatic and subaquatic vegetation communities, that are not, for this reason, considered climax communities. Nevertheless, there are certain positive factors to support the hypothesis that different types of aquatic and subaquatic vegetation can serve as the criteria by which the wetlands of the coastal region of the Gulf of Mexico may be named and classified.

The main element in favor of this type of classification is the relative ease with which an observer can distinguish the different landscapes and physiognomic characteristics of the dominant vegetation communities of most wetlands. For this purpose, it is important to

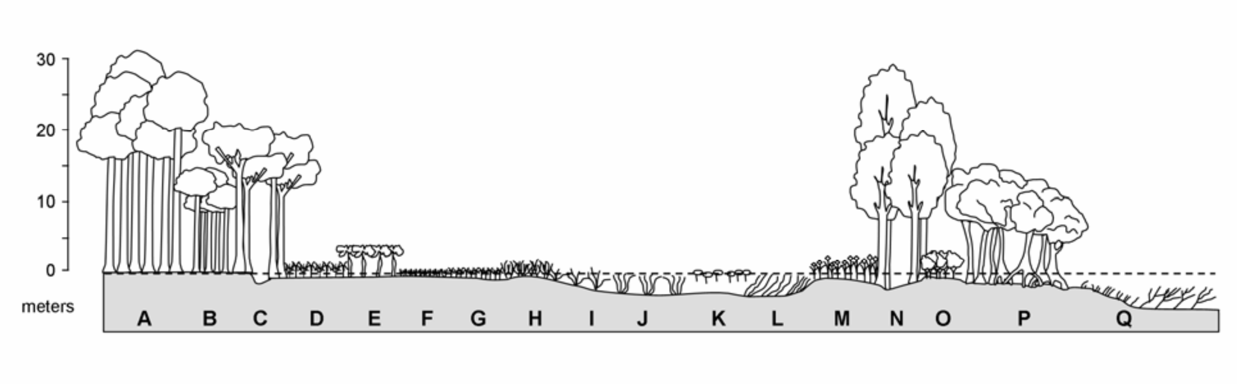

Fig. 16.1. Diagrammatic profile of aquatic vegetation distribution/zonation in the central and southern regions of the Gulf of Mexico. A: Subtropical forest dominated by *Andira*; B: Tropical dry forest dominated by *Annona*; C: *Salix*-evergreen riparian forest; D: *Thalia-Pontederia* rooted emergent hydrophytes; E: *Acoelorrapahe* floodable palms; F. *Eleocharis* rooted emergent hydrophytes; G: *Mimosa* floodable thorny scrub; H: *Typha-Scirpus* rooted emergent hydrophytes; I: *Nelumbo* and other floating leaved hydrophytes; J. *Nymphea-Nymphoides* and other floating leaved hydrophytes; K: *Eichhornia*, *Pistia*, *Lemma* and other free floating hydrophytes; L: *Potamogeton*, *Najas*, *Utricularia* and other submerged hydrophytes; M: *Phragmites* and other emergent rooted hydrophytes; N: *Pachira-Ficus* medium level riparian forest; O: *Dalbergia* floodable thornless scrub; P: *Rhizophora*, *Avicennia*, *Laguncularia*, and *Conocarpus* mangrove forest; Q: *Vallisneria*, *Ruppia*, *Thalassia*, and *Halodule* submerged hydrophytes.

remember the rich array of vernacular names that local inhabitants give to vegetation groups around the world. In the state of Veracruz, for example, there are more than 13 names for some wetland communities (Lot 1991). Abundance and the frequent covering of vast expanses with one or several species or species associations, constitute the common element unifying popular perception and scientific knowledge concerning the definition of certain characteristics for naming and distinguishing between different landscapes of each type of wetland. On the other hand, the distribution of certain vegetation associations reflects a series of geomorphological, climatic, ecological, and hydrological factors, which exist over time and across space and play a crucial role in the evolution of these wetlands. The following are the principal wetlands based on two large types of vegetative groups: woody and herbaceous formations.

WOODY FORMATIONS

These include groups of trees and shrubs as well as palms adapted to poorly-drained soils that develop in zones that are permanently or temporarily flooded during six months of the year. A sizable group of woody elements, principally trees and shrubs, constitute different types of communities as dominant or accompanying elements in forests and other types of vegetation, including terrestrial areas. For this reason the ability of some species to adapt to both environments as ecological forms should be taken into account.

Rain Forest

The alluvial plains of southeastern United States, mostly on the Gulf coast, contain woody communities of subtropical or temperate regions, characterized by the presence of the genera *Pinus, Taxodium* and *Nyssa*. *Pinus elliottii* var. *densa* occupies large areas of the lower terraces of the coastal plains of the Mississippi and extreme south of Florida where waters are 0.3-2 m deep. It is believed that fire, as a periodic natural phenomenon, has played an important part in the evolution and floristic composition of this formation (Penfound 1952; Olmsted and Loope 1984).

The so-called cypress forests are another type of vegetation typically found in the deepwater swamps of the Everglades National Park in Florida where predominant species are *Taxodium distichum* and *Nyssa aquatica.* This association can also be found in the flood zones on the margins of the Mississippi river. Another important association is that of *Nyssa selvatica* var. *biflor* and *Taxodium ascendens*, that is mostly found in the highest parts of the coastal plains of the Gulf. The dominant woody forms of this type of forest have pneumatophores, similar to those produced by some mangrove trees. These trees grow to heights of 6-12 m. According to Penfound (1952), *Taxodium-Nyssa* associations probably occur during initial successional stages in this type of rainforests, later to be replaced by other communities in temporarily flooded soils and well-drained soils where *Pinus palustris* and *P. caribaea* predominate.

Riparian Forest

These are woody communities that develop in fertile, floodable lowlands and especially on the banks of rivers and streams running from higher elevation areas down to the mouths of coastal lagoons and the sea. For this reason, they are common along all the coastal plains of the Gulf of Mexico where rivers are abundant. Associations of the willows *Salix negra, S. caroliniana* and *S. chile* are dominant (the latter is found in southern Mexico) and *Cephalanthus occidentalis* appears as an accompanying shrub element, especially in disturbed areas. In the lower Mississippi flood plains, other types of transitional forests are found, where dominant genera include *Liquidambar styrciflua, Quercus palustris* and *Platanus occidentalis*. Some species of these genera can be found as riparian elements in the higher regions of the mountains of Veracruz.

High-Intermediate Riparian Forest

This type of vegetation is found in all its various forms in the tropical region of Mexico on deep, well-drained soils, but also on thin soils that are flooded periodically, although its floristic composition may vary from one condition to the other. The characteristic species that tolerate flooding and that can reach heights of 25 m or more include *Pachira aquatica, Andira galeottiana, Vochisia guatamalensis, Calophyllum brasiliense* and some species in the genera *Lonchocarpus, Pithecelobium, Inga, Ficus* and *Machaerium.* An important variant of this type of intermediate forest found in southern Tabasco is one known locally as the *Bravaisia integerrima* swamp (“canacoital”).

Low Floodable Forest

Low floodable forests are broadly represented communities that cover significant areas in numerous flood plains of the Gulf, although locally they cover small areas that contain water most of the year but also suffer periods of extreme drought. The trees and shrubs that constitute this type of vegetation are 6-8 m high, often without stratification and some of their elements buttressing at the base of their trunk.

Along the Río Palizada in Campeche, one of the most characteristic communites can be found, made up of monotypic *Annona glabra* (Ocaña and Lot 1996); in Veracruz and Tabasco other accompanying woody species such as *Dalbergia brownei, Ficus padofolia, Lonchocarpus pentaphyllus* and *Chrisibalanus icaco* can be found.

The most common community in the past, that stretched from southern Veracruz to the Yucatan Peninsula, was the lowland riparian forest ("tintal"), but nowadays it has been drastically reduced by agricultural activity and overexploitation of the tree *Haematoxylum campechianum*. Other representative communities of low floodable forests are the *Metopium brownei* "chechenal", the *Bucida buceras* "pucktal" (Lot and Novelo 1990) and the *Bucida spinosa* "bucidal" (Olmsted and Duran 1986) with a total of 65 documented woody species and an abundance of epiphytes at the Sian Ka'an Biosphere Reserve in Quintana Roo.

This type of vegetation is also important for forming ecotones with other vegetation communities formations such as mangroves, savannahs, palm groves, scrub and, of course, intermediate and high forest, which is why there may be some common floristic elements.

The "peten" can be classified under this type of vegetation because it is the only type of forest in southern Florida appears (Olmstead and Duran 1988). Although this particular community is known as hammock on the Florida Peninsula or peten in the Mesoamerican region, it is really an island of forest surrounded by a swamp containing mangroves, palms and other woody and herbaceous species adapted to flooding. These islands of vegetation have played an important role in providing Florida Native Americans (Olmstead and Duran 1988) and the Mayas (Barrera 1982) with a habitat and natural resources, and today they serve as a refuge for local fauna.

Floodable Palm Grove

One common element in floodable depressions throughout the Gulf, including Cuba, is the silver saw palm *Acoelorrhaphe wrightii.* These plants can reach heights of 8 m but more frequently grow to 2-5 m, semi-submerged in a water 0.5-1.5 m deep for at least nine months of the year and with a totally dry surface during the low water period, when fires are more likely to break out. At the limits of the high forests, on floodable argillaceous soil, some palms such as *Roystonea regia, R. dunlapiana* and *Attalea butyracea* can be found. These are known generically as royal palms.

SAVANNAH

There are various types of savannah with different origins including those of anthropogenic origin. Most savannahs grow on great extensions of plains, or, with slight microtopographical changes, in deep, poorly drained argillaceous soils that flood for six or more months of the year and are completely dry during droughts. The landscape is normally a dense formation of sedges and grasses plants with some trees or silver saw palms growing in isolation or forming small islands or borders. This landscape of apparent rhizomatous grass may result from constant burning of the land and grazing carried out over many decades (Orozco and Lot 1976). The most prominent woody species on the savannahs of the coastal plain of the Gulf include *Quercus oleoides* on the least flooded borders and *Coccoloba barbadensis* in the north of Veracruz (Rzedowski 1978). The dominant herbaceous species, apparently reinforced by human activity and that form almost monotypic communities that have gradually been replacing the diverse communities of hydrophytes, is *Cladium jamaicense*.

Floodable Scrub

Mimosa pigra scrub is a very dense, thorny community with few accompanying species. It grows in warm humid regions on the coastal plain of the Gulf of Mexico where there is constant human disturbance. Other types of scrub adapted to flooded conditions are the *Dalbergia brownei* and *D. glabra* “mucal”; the former on the Veracruz and Tabasco shoreline (Lot and Novelo 1990), and the latter in Quintana Roo (Olmstead and Duran 1986). The *Bravaisia tubiflora* “julubal” is another indicator of human interference in river channels. One shrub that grows to less than 2 m is *Cephalanthus occidentalis*, a frequent secondary species on the periphery of diverse types of vegetation throughout the Gulf of Mexico.

HERBACEOUS FORMATIONS

The main groups are presented based on their adaptation into different vegetative forms and their relationship to aspects of the dynamic of communities in terms of the zonation and succession of wetlands.

Emergent Rooted Hydrophytes

Practically all habitats in the innumerable lacustrine and palustrine systems on the coastal plains of the Gulf, show associations where the dominant element is a hydrophyte rooted in the substrate with leaves and reproductive structures that emerge above the water. This type of vegetation represents the most important freshwater wetland on the landscape due to its function as a refuge for aquatic fauna and habitat for numerous rare aquatic plants that, in many cases, are in danger of extinction. They are popularly known in the region by various common names. This is the case of the *Typha* species which only in Mexico are known by their vernacular names of “tule”, “espadña”, “neal” and “chuspatal” combined with adjectives to distinguish between species; in Cuba they are known as the “macio” and in the U.S. as “cattail”. These communities are known generically as “tulares”. Other communities include willows, reeds and floodable lowland vegetation, among others. The genera represented, in some cases with numerous species in a community, include *Typha*, *Schoenoplectus*, *Scirpus*, *Thalia*, *Phragmites*, *Arundo*, *Cladium*, *Cyperus*, *Eleocharis*, *Carex*, *Sparganium*, *Pontederia*, *Spartina*, *Paspalum*, and *Rhynchospora* among others.

The *Cladium jamaicense* “sibal” stands out from many other associations due to its abundance and tolerance to diverse wetland environments with soils containing varying concentrations of dissolved salts and with high sulfur contents. In addition to covering large areas as monotypic communities, it is also present in mangrove, savannah and palm grove zones on all the coastal plains of the Gulf from Florida and Cuba down to the Yucatán Peninsula.

Prominent in the acidic swamps of the center and north of Florida are populations of carnivorous plants of genus *Sarracenia*, with six known species.

Rooted Floating-Leaf Hydrophytes

Plants exhibiting this life form are represented by numerous communities in lakes, lagoons, canals and areas of deep, open wetlands. Most of this community's significant species belong to the genera *Nymphaea, Nuphar, Nymphoides, Brasenia*, although some belong to *Potamogeton* and *Sagittaria*. The *Nymphaea ampla* association is one of the most important due to its abundance in freshwater environments in the Gulf of Mexico and also in lagoons and floodable lowlands of variable salinity close to coastal areas where even mangroves grow.

Submerged Rooted Hydrophytes

This type of vegetation, like the emergent hydrophytes, is important for wildlife conservation, because it provides shelter to aquatic birds and, in general, provides food, nursery areas and refuge for most groups of vertebrates and invertebrates in wetlands. The marine grasses that grow in coastal lagoons and coral reefs also belong to this life form. Some of the numerous genera that are well represented in the submerged plants are *Potamogeton, Vallisneria, Egeria, Hydrila, Myriophyllum, Cabomba, Mayaca* and *Zannichellia*. The genera *Ruppia* and *Najas*, represented by *R. maritima* and *N. marina*, grow mainly in saline and alkaline environments but not marine environments.

Some associations exhibit massive growth and may be indirectly encouraged by man, causing serious damage to navigation and irrigation water control structures and as invasive exotics, which replace native flora. Prominent among these is *Hydrilla verticallata*, a real plague in the U.S. and one that has started to emerge for the first time in Mexico (Tamaulipas) (Novelo and Martínez 1989). Some species of *Egeria, Potamogeton, Myriophyllum* and *Najas* can also cause problems in terms of invasion and undesirable growth in bodies of water managed by man. The Podostemaceae consists of a small group of plants that inhabit waterfalls and rapids and are indicative of clean water and well-preserved environments.

Free-Floating Hydrophytes

The distribution of communities representing this life form depends on the wind and on currents in lakes, lagoons and rivers. For this reason, they can be very patchy and their abundance can be difficult to quantify. In some cases, particularly where there is human interference, some species form monotypic communities, which displace other native populations, resulting in low diversity of aquatic flora. The clearest example of this is the water hyacinth, *Eichhornia crassipes*, an exotic, naturalized plant, which invades wetlands in tropical and subtropical regions. An example of phytogeographic interest is a rare South American plant of the Euphorbiaceae family, *Phyllanthus fluitans*, which appears throughout the swamps of Tabasco (Lot *et al.* 1980). Other plants constituting important communities include *Pistia stratiotes, Neptunia oleraceae*, species in the genera *Lemna, Wolffia, Wolffiella, Spirodela* and the fern genera *Azolla* and *Salvinia*.

Unrooted Submerged Hydrophytes

These plants do not form important associations but locally they can cover large areas in bodies of water of a certain depth, for example *Ceratophyllum* species. This life form includes the so-called carnivorous plants in the genus *Utricularia*, with more than 20 species.

WETLAND FLORA AND ITS CONSERVATION

In Appendices 1 and 2 there are lists of woody and herbaceous species with their distributions throughout the six large, regional subdivisions considered in this chapter. The list is by no means exhaustive but, all the same, it gives us an idea of the floristic richness of the wetlands of the Gulf of Mexico. The list is based on information taken from various publications, including León (1946), Shaw and Fredine (1971), Lot *et al.* (1980, 1999), Rico-Gray (1982), Dressler *et al.* (1987), Lot and Novelo (1988), Reed (1988), Martínez and Novelo (1993), Olmsted (1993), Olvera (1996), Guadarrama and Ortiz (2000), Diego-Pérez *et al.* (2001), and Martínez and Galindo Leal (2002). At first sight, this list of aquatic and subaquatic wetland species gives us an idea of the great number of vascular plants belonging to the palustrine, lacustrine and riparian environments of the Gulf. A good number of these are common to regional subdivisions but it is also clear that some groups of species are restricted to one or two regions and are, in many cases, endemic.

Table 16.1 summarizes the number of woody and herbaceous genera and species listed in Appendices 1 and 2. These preliminary figures are indicative of the richness of each region but should not be taken as definitive since the methods used in each study are not the same. On the other hand, the number of publications and botanical collections, and their accessibility, also explains, in part, better studied regions, although not necessarily with greater diversity.

The diversity of species and biological forms is remarkable and shows a great spectrum, representing not only different taxa, but also the variety of shrubs, trees, climbers, emergent, submerged and floating rooted herbaceous plants, some with prostate stems, others freely floating or submerged. This preliminary list includes 82 woody and 130 herbaceous genera, which is indicative of the fact that the number of species in the wetland flora of the Gulf of Mexico must be over 1000 vascular plants.

Hydrophyte communities play a crucial role in feeding, nesting, sheltering and reproduction of innumerable elements of wetland fauna. For this reason accelerated destruction and modification of these communities can cause irreparable losses to the biodiversity of an important region of the American Atlantic.

DEDICATION

In memory of Ingrid Olmsted, a tenacious student of the wetlands of the Gulf of Mexico.

Table 16.1. Preliminary count of the numbers of genera and species documented in each region based on species checklists included in Appendices 1 and 2.

Region	Woody		Herbaceous		Total	
	Genera	Species	Genera	Species	Genera	Species
Florida	44	55	98	200	139	255
Mississippi	4	4	61	131	65	135
Central Gulf	38	52	77	156	115	208
Usamacinta	31	35	62	102	19	27
Yucatan Peninsula	18	20	19	27	37	47
Cuba	21	23	56	117	77	140

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Appendix 16.1. Alphabetical checklist of woody flora from the wetlands in the Gulf of Mexico.

Species	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatan Peninsula	Cuba
Acoelorraphe wrightii			X	X	X	X
Aeschynomene deami			X			
Aeschynomene sensitiva	X			X		X
Alnus serrulata	X					
Andira galeottiana			X			
Annona glabra	X		X	X		
Aspidosperma cruentum					X	
Aster carolinianus	X					
Astianthus viminalis			X			
Ateleia gumífera					X	
Betula nigra	X					
Bravaisia berlandieriana			X	X	X	
Bravaisia tubiflora			X		X	X
Bucida buceras			X	X	X	X
Byrsonima crassifolia				X	X	
Calophyllum brasiliense			X		X	
Calyptranthes perlaevigata			X			
Calyptrogyne dulcis						X
Callicarpia dichotoma	X					
Cameraria latifolia	X				X	
Carpinus caroliniana	X					
Carya aquatica	X					
Cephalanthus occidentalis	X	X	X	X		X
Cephalanthus salicifolius			X			
Clethra alnifolia	X					
Combretum laxum			X	X		X
Crataegus aestivalis	X					
Crataegus marshallii	X					
Cynometra retusa			X	X		
Cyrilla raceuniflora	X	X				
Chamaecyparis thyoides	X					
Chrysobalanus icaco			X			
Dalbergia brownei			X	X		X
Dalbergia glabra			X	X	X	
Decodon verticillatus	X					
Diospyros digyna			X			
Erytrina fusca						
Ficus cotinifolia			X			
Ficus glabrata			X			
Ficus maxima				X		
Ficus obtusifolia			X		X	

Appendix 16.1. Continued.

Species	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatan Peninsula	Cuba
Ficus padifolia			X			
Fraxinus caroliniana	X					
Fraxinus chiapensis			X			
Fraxinus uhdei			X			
Gleditsia aquatica	X					
Gordonia lasianthus	X					
Gymnopodium floribundum				X		
Haematoxylum campechianum			X	X	X	X
Hibiscus tiliaceus						X
Hibiscus urbanii						X
Hydrolea cubana						X
Hypericum chapmanii	X					
Hypericum lissophoeus	X					
Hypericum nitidum	X					
Ilex cassine	X					X
Ilex coriaceae	X					
Ilex decidua	X					
Ilex myrtifolia	X					
Ilex opaca	X					
Inga vera			X	X		
Itea virginica	X					
Iva frutescens	X					
Ixora coccinea				X		
Jacquinia aurantiaca			X	X		
Leucothoe papulifolia	X					
Litsea aestivalis	X					
Lonchocarpus castilloi					X	
Lonchocarpus hondurensis			X	X		
Lonchocarpus luteomaculatus			X	X		
Lonchocarpus xuul					X	
Machaerium falciforme			X	X		
Magnolia virginiana	X					
Malpighia lundellii					X	
Malvaviscus arboreus var. *brihondus*			X	X	X	
Metopium brownei					X	X
Metopium goxiferum	X					X
Mimosa pigra	X		X	X		X
Nectandra glabrescens				X		
Nyssa aquatica	X					
Nyssa ogeche	X					
Nyssa sylvatica var. *biflora*	X					

Appendix 16.1. Continued.

Species	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatan Peninsula	Cuba
Ouratea nitida				X	X	
Pachira aquatica			X	X		
Persea palustris	X					
Pinckneya bracteata	X					
Pinus serotonina	X					
Pithecelobium dulce			X			
Pithecelobium pachypus			X			
Pithecellobium brownii				X		
Pithecellobium kellense				X		
Pithecellobium oblongum				X		
Planera aquatica	X					
Platanus mexicana			X			
Platanus occidentalis	X					
Platanus rzedowskii			X			
Populus heterophylla	X					
Populus mexicana			X			
Prosopis juliflora			X			
Quercus lyrata	X					
Roystonea dunlapiana			X	X		
Roystonea regia	X				X	X
Salix bonplandiana			X			
Salix caroliniana	X					X
Salix chilensis			X	X		
Salix exigua			X			
Salix floridana	X					
Salix humboldtiana			X			X
Salix humilis	X					
Salix nigra	X					
Salix taxifolia			X			
Sambucus canadensis	X	X				
Sesbania emerus	X		X	X		X
Sesbania sericea	X					X
Symphonia globulifera			X			
Tabebuia gracilipes						X
Tabebuia rosea			X	X	X	
Talisia florestii					X	
Taxodium ascendens	X					
Taxodium distichum	X					
Taxodium mucronatum			X			
Thevetia ahouai			X	X		
Thevetia gaumeri				X	X	

Appendix 16.1. Continued.

Species	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatan Peninsula	Cuba
Vaccinium corymbosum		X				X
Viburnum acerifolium	X					
Vochysia hondurensis			X			
Zygia longifolia				X		

Appendix 16.2. Alphabetical checklist of herbaceous flora from the wetlands in the Gulf of Mexico.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Acorus americanus		X				
Alternanthera philoxeroides	X					
Amaranthus australis	X					
Andropogon glomeratus				X		
Aster elliottii	X					
Aster subulatus	X					
Aster tenuifolius	X					
Bacopa caroliniana	X					
Bacopa innominata	X					X
Bacopa monnieri	X	X	X	X		X
Bacopa procumbens				X		X
Bacopa repens			X	X		
Bergia texana		X				
Bidens aurea			X			
Bidens laevis	X					
Bidens mitis	X					
Bletia purpurea			X	X		
Borrichia arborescens	X					
Borrichia frutescens	X					
Brasenia schreberi	X	X	XX			X
Cabomba caroliniana	X	X	X	X		X
Cabomba palaeformis			X	X	X	
Canna glauca	X	X	X	X		X
Caperonia palustris	X	X				X
Carex (41 wetland species)	X	X	X	X	X	X
Ceratophyllum demersum	X	X	X	X		X
Ceratophyllum echinatum	X	X				X
Ceratophyllum muricatum	X		XX			
Cicuta mexicana	X					
Cladium jamaicense	X	X	X	X		X
Colocassia esculenta		X				
Coreopsis nudata	X					
Crinum americanum	X					
Crinum erubescens			X	X		
Cyperus articulatus	X	X	X	X		X
Cyperus canus			X	X		
Cyperus digitatus	X	X	X			X
Cyperus distans	X	X				
Cyperus elegans			X			

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Cyperus esculentus			X			X
Cyperus flavescens	X	X				
Cyperus gardneri				X		X
Cyperus giganteus	X	X	X	X		X
Cyperus haspan	X	X		X		X
Cyperus imbricatus				X		X
Cyperus macrocephalus				X		
Cyperus niger			X			
Cyperus ochraceus			X	X		X
Cyperus odoratus			X	X		X
Cyperus surinamensis				X		
Datura ceratocaula						X
Didiplis diandra	X	X		X		
Drosera brevifolia	X	X				
Drosera capillaris	X	X	X			X
Drosera filiformis	X	X				
Drosera intermedia	X	X				
Drosera rotundifolia						XX
Echinichloa holciformis				X		
Echinochloa colona			X			
Echinochloa polystachia				X		
Echinodorus andrieuxii			X	X	X	
Echinodorus berteroi			X		X	
Echinodorus cordifolius	X	X	X		X	
Echinodorus nymphaeifolius					X	
Echinodorus ovalis			X		X	
Echinodorus paniculatus			X	X		
Echinodorus parvulus	X	X				
Echinodorus rostratus	X	X				
Echinodorus tenellus			X			
Eclipta postrata			X			
Egeria densa	X		X		X	
Eichhornia azurea	X	X	X	X		X
Eichhornia crassipes	X	X	X	X	X	X
Eichhornia diversifolia						X
Eichhornia heterosperma						X
Eichhornia paniculata						X
Eleocharis caribea	X	X				X
Eleocharis cellulosa	X	X		X		X
Eleocharis elegans				X		
Eleocharis fallax	X	X				

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Eleocharis fistulosa			X			X
Eleocharis flavescens	X	X				X
Eleocharis interstincta	X	X	X			X
Eleocharis macrostachya			X			
Eleocharis montana	X	X				
Eleocharis montevidensis			X			
Eleocharis mutata	X	X	X	X		X
Eleocharis retroflexa	X	X				X
Eleocharis rostellata	X	X				X
Elodea canadensis	X	X				
Eriocaulon compressum	X					
Eriochloa punctata			X			
Eupatorium betoncifolium				X		
Fimbristylis ferruginea						X
Fimbristylis miliacea	X	X				X
Fimbristylis simplex				X		
Fuirena scirpoidea	X					X
Fuirena squarrosa	X					X
Fuirena umbellata						X
Gratiola virginiana			X			
Habenaria bractescens			X			
Habenaria ciliaris	X	X				
Habenaria cristata	X	X				
Habenaria nivea	X	X				
Habenaria pringlei			X	X		
Habenaria repens	X	X	X	X		X
Heteranthera dubia			X	X		X
Heteranthera limosa	X	X	X		X	X
Heteranthera mexicana			X			
Heteranthera oblongifolia						X
Heteranthera peduncularis			X			
Heteranthera reniformis	X	X	X	X		X
Heteranthera rotundifolia			X		X	X
Heteranthera seubertiana					X	
Hibiscus grandiflorus	X					
Hydrcotyle bonariensis	X	X	X			
Hydrilla verticillata	X		X			
Hydrochloa caroliniensis	X					
Hydrocotyle pusilla						X
Hydrocotyle ranunculoides	X					X
Hydrocotyle umbellata	X	X	X	X		X

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Hydrocotyle verticillata	X	X	X	X		X
Hydrolea corymbosum	X					
Hydrolea quadrivalvis	X					
Hydrolea spinosa				X		X
Hydrolea uniflora	X					
Hydromystria laevigata				X		
Hygrophila lacustris	X					
Hygrophila polysperma	X					
Hymenanchne amplexicaulis	X	X				
Hymenocallis latifolia	X					
Hymenocallis littoralis			X			
Ipomoea acuatica	X					
Ipomoea fistulosa			X	X		
Iris hexagona	X					
Iris virginica	X					
Iva annua	X					
Juncus acuminatus	X	X				
Juncus coriaceus	X	X				
Juncus dichotomus	X	X				
Juncus effusus	X	X				
Juncus gymnocarpus	X					
Juncus marginatus	X	X				
Juncus megacephalus	X	X				
Juncus repens	X	X				X
Juncus romerianus	X	X				
Juncus scirpoides	X	X				
Juncus tenuis	X	X				
Juncus validus	X	X				
Justicia americana	X					
Justicia comata				X		X
Justicia ovata	X					
Kosteletzkya virginica	X					
Lachnocaulon anceps	X	X				
Leersia hexandra	X	X	X	X		
Lemna aequinoctialis			X	X	X	
Lemna gibba			X			
Lemna minor	X		X			
Lemna perpusilla	X	X				X
Lemna trinervis	X	X				
Lemna trisulca	X					X
Lemna valdiviana	X	X				

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Leptochloa fascicularis			X			
Lilaeopsis carolinensis	X					
Lilaeopsis chinensis	X					
Lilaeopsis occidentalis			X			
Limnobium spongia	X	X				
Limnocharis flava			X			X
Limonium carolinianum	X					
Limosella aquatica			X			
Lindernia alterniflora						X
Lindernia dubia	X	X				X
Lindernia grandiflora	X					
Lindernis antipoda				X		
Lobelia cardinalis	X		X	X		
Lobelia glandulosa	X					
Lobelia purpusii			X			
Ludwigia decurrens	X	X		X		X
Ludwigia erecta	X	X		X		
Ludwigia helmintorrhiza				X		
Ludwigia leptocarpa	X	X	X	X		X
Ludwigia natans			X			X
Ludwigia octovalis	X	X		X		
Ludwigia palustris	X	X				X
Ludwigia peploides	X	X	X	X		
Ludwigia peruviana	X	X	X			X
Ludwigia repens			X			X
Ludwigia suffruticosa			X			X
Marathrum schiedeanum			X			
Marathrum tenue			X			
Mayaca fluviatilis			X			
Melanthera aspera				X		
Micranthemum umbrosum	X	X				
Mikania scandens	X					
Mimulus glabratus			X			
Monanthochloe littoralis	X					
Muhlenbergia capillaris	X					
Myriophyllum aquaticum	X		X			
Myriophyllum heterophyllum	X			X		X
Myriophyllum laxum	X					X
Myriophyllum pinnatum	X		X			X
Myriophyllum sparsiflorum						X
Myriophyllum spicatum	X					

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Najas guadalupensis	X	X	X	X		X
Najas marina	X	X	X	X	X	X
Najas wrightiana				X		X
Nasturtium microphyllum	X					
Nasturtium officinale	X	X	X			X
Nelumbo lutea	X	X	X	X		X
Nelumbo nucifera	X	X				
Neptunia oleracea			X			
Neptunia plena				X		
Nuphar advena	X	X				X
Nuphar luteum	X	X	X			
Nymphaea amazonum			X			X
Nymphaea ampla	X	X	X	X	X	X
Nymphaea conardii			X			
Nymphaea elegans		X	X			
Nymphaea jamesoniana	X	X	X	X		X
Nymphaea mexicana		X				
Nymphaea odorata	X	X	X	X		X
Nymphaea prolifera			X			
Nymphaea pulchella						X
Nymphaea rudgeana						X
Nymphaea speciosa			X	X		
Nymphoides aquatica	X					
Nymphoides cordata	X					
Nymphoides grayana						X
Nymphoides indica			X	X	X	X
Orontium aquaticum	X	X				
Oryza latifolia			X			X
Oxycarium cubense			X			
Oxypolis filiformis	X					
Panicum aquaticum				X		
Panicum gymnocarpon	X					
Panicum maximum				X		
Paspalum distichum			X			
Paspalum vaginatum	X	X	X			
Peltandra sagittifolia	X	X				
Peltandra virginica	X					
Phragmites australis	X	X	X	X		
Phyllanthus fluitans			X	X		
Pistia stratiotes	X	X	X	X		X
Pluchea purpurascens				X		

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Podostemum ricciiforme			X			
Polygonum acuminatum			X	X		X
Polygonum densiflorum			X			
Polygonum ferrugineum			X			X
Polygonum hydropiperoides	X	X	X			
Polygonum mexicanum			X			
Polygonum punctatum			X			
Polygonum virginianum			X			
Pontederia cordata	X	X				
Pontederia parviflora						X
Pontederia rotundifolia			X			
Pontederia sagittata			X	X	X	
Potamogeton foliosus	X	X	X	X		X
Potamogeton illinoensis			X	X	X	
Potamogeton nodosus	X	X	X	X		X
Proserpinaca palustris	X		X			X
Proserpinaca pectinata	X					X
Ranunculus cymbalaria			X	X		
Ranunculus dichotomus			X			
Ranunculus flabellaris		X				
Ranunculus laxicaulis		X				
Ranunculus longirostris		X				
Ranunculus pusillus		X				
Ranunculus sceleratus		X				
Rhynchospora alba	X	X				
Rhynchospora colorata			X			
Rhynchospora inundata			X			
Rhynchospora odorata	X	X				X
Rotala ramosior	X	X				
Ruppia maritima	X	X	X	X	X	X
Sabatia dodecandra	X					
Sacciolepsis striata	X	X				
Sagittaria guayanensis			X	X		
Sagittaria intermedia				X		X
Sagittaria lancifolia	X	X	X	X	X	X
Sagittaria latifolia			X	X		
Sagittaria longiloba			X			
Sagittaria montevidensis			X	X		
Samolus ebracteatus	X					
Samolus parviflorus	X		X			
Sarracenia flava	X	X				

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Sarracenia leucophylla	X	X				
Sarracenia minor	X					
Sarracenia psittacina	X					
Sarracenia purpurea	X	X				
Sarracenia rubra	X					
Saururus cernuus	X	X				
Schoenoplectus americanus	X	X	X			X
Schoenoplectus californicus			X			
Schoenoplectus lacustris			X			
Schoenoplectus tabernaemontani	X	XX	X			X
Scirpus cubensis				X		
Scirpus cyperinus	X					
Scirpus erismanae	X					
Scirpus olneyi	X					X
Scleria cubensis						X
Scleria latifolia				X		
Scleria reticularis	X	X				X
Sium suave	X	X				
Sparganium americanum	X					
Spartina alterniflora	X					
Spathiphyllum cochlearispathum			X			
Sphenoclea zeylanica	X	X	X	X		X
Spirodela intermedia			X	X		
Spirodela polyrhiza	X	X	X	X		X
Spirodela punctata	X	X				
Stuckenia pectinata			X			
Thalia geniculata	X	X	X	X		
Triadenum virginicum	X					
Tristicha trifaria			X			X
Typha angustifolia	X	X				
Typha domingensis	X	X	X	X	X	X
Typha latifolia	X	X	X			
Utricularia cornuta	X	X				X
Utricularia foliosa			X	X	X	
Utricularia gibba	X	X	X	X		
Utricularia hidrocarpa			X	X		
Utricularia hispida			X			
Utricularia inflata	X	X				
Utricularia juncea	X	X	X	X		X
Utricularia macrorhiza		X				
Utricularia obtusa						X

Appendix 16.2. Continued.

	Florida	Mississippi	Central Gulf of Mexico	Usumacinta	Yucatán Peninsula	Cuba
Utricularia olivacea	X					X
Utricularia purpurea	X	X		X	X	X
Utricularia pusilla			X			X
Utricularia radiata	X	X	X			
Utricularia resupinata	X	X	X			
Utricularia simulans						X
Utricularia striata	X	X				
Utricularia subulata				X		X
Vallisneria americana	X		X	X	X	X
Wedelia trilobata				X		
Wolffia brasiliense			X		X	
Wolffia columbiana		X	X		X	X
Wolffia papulifera	X	X		X		
Wolffia punctata	X					
Wolffiella floridana	X	X				
Wolffiella gladiata	X					
Wolffiella lingulata			X	X		
Wolffiella oblonga	X		X	X		
Wolffiella welwitschii			X			
Xanthosoma robustum			X			
Xyris (16 wetland species)	X					
Zannichellia palustris			X			X
Zizania aquatica	X					
Zizaniopsis miliaceae	X		X			