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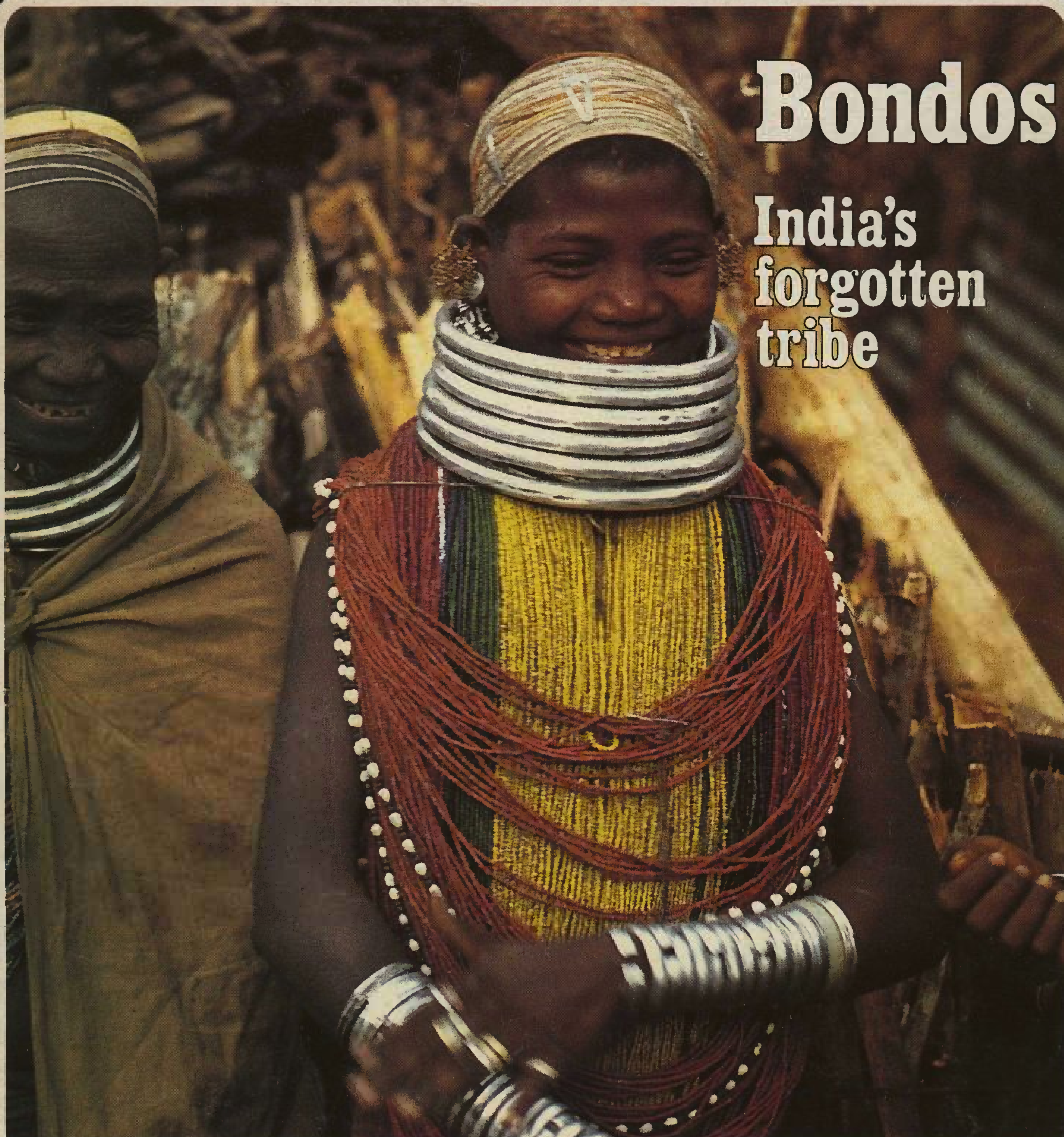

Bondos

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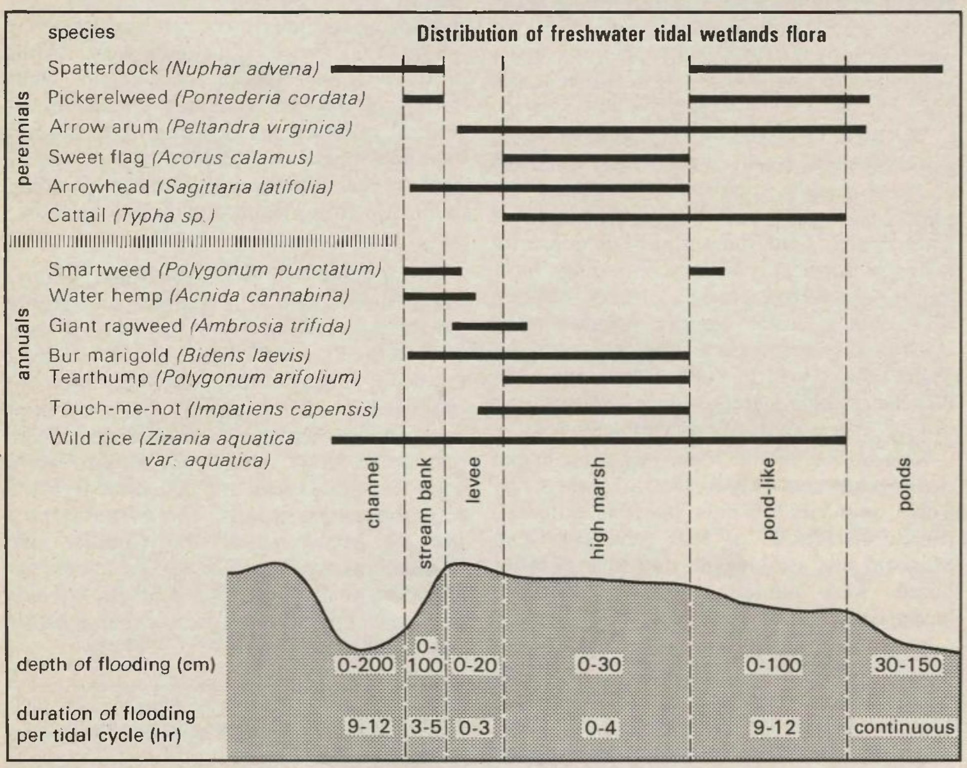
Wetlands
OF THE WORLD

The long wetland by Dennis F. Whigham

The eastern seaboard of North America is one of the longest expanses of wetland in the world. Dennis F. Whigham describes the ecosystems found there

MOST LARGE wetland complexes on the east coast of the USA were formed as the result of glacial activity that began approximately 200,000 years ago when most of the northeast was under ice. The Atlantic Ocean was 125 metres below its current level then and terminal moraines created Long Island and Cape Cod during this period. The last glacial retreat marked the beginning of development of the existing wetland patterns. Sea level began to rise about 10,000 years ago and drowned numerous river valleys forming the large estuaries of the Hudson and Delaware Rivers, and the major rivers that drain into the Chesapeake Bay. Other events associated with glacial activity led to the formation of numerous barrier beaches behind which formed large coastal lagoons from North Carolina to Florida. Those estuaries and lagoons now form the coastal system that includes most of the wetlands from the Bay of Fundy through the eastern coastal states to Florida and into the Gulf of Mexico.

Inland from present tidal influence are areas that were formed by other events during the Pleistocene. The 16,500,000 hectare Okefenokee Swamp in Georgia was originally covered by brackish water but over the centuries it was transformed into a freshwater habitat that now contains a variety of herbaceous and forested wetlands. Still other wetlands formed within the coastal zone. Bottomland hardwood forests developed along all of the sluggish coastal



The dominant species of vegetation in Georgian salt marshes is smooth cordgrass (*Spartina alterniflora*); two distinct forms occur. (Above) the taller variety grows along creekbanks near Sapelo Island where there is a tidal range of between 2 and 3 metres

(Right) late summer in Hamilton Marshes, New Jersey. Water lily and plant-bur marigold bloom on the stream bank and the high marshes respectively streams throughout the southeastern states. In North Carolina and parts of South Carolina, peat began to accumulate in the coastal plain areas between 10,300 and 8000 years ago, as the gradual rise in sea level inundated stream valleys and reduced water table gradients.

Peat initially formed in depressions between old Pleistocene dunes and ridges and eventually it even mantled interstream uplands to form a wetland complex that is known by the term *Pocosin* or 'Swamp-on-a-hill'. North Carolina is the site of 70 per cent of the Pocosin wetland area in North America and at one time it had an estimated 907,933 hectares of these lands. Pocosin areas are now being converted to forest plantations and large agribusiness farms at an alarming rate. Peat abstraction for fuel and alcohol production is a distinct possibility for the future. Today North Carolina has only 281,000 hectares of unaltered Pocosin area and less than 5 per cent of the resource is currently protected from development.

To many people, the most important feature of the coastal state are the vast expanses of tidal wetlands. These range from tidal freshwater areas, where salinity is less than 0·5 parts per thousand (ppt), to saline coastal wetlands which are regularly inundated by 35 ppt water. The plant life growing in any particular wetland depends primarily on the seasonal pattern of salinity and the intensity of tidal flooding. A good impression of the effects that salinity and tidal activity have on tidal wetlands can be gained by comparing coastal wetlands of Georgia with wetlands in the Maryland portion of the Chesapeake Bay.

In Georgia vast salt marshes have formed in lagoonal areas behind barrier islands. The lagoonal system in Georgia is characterized by a wide tidal range of between two and three metres which greatly affects marsh

development. Relatively high natural levees are formed near the streams where tidal ranges are large. The levees, in turn, affect the movement of water onto other portions of the wetland and result in water tables that are very near the surface over much of the irregularly flooded portions of the wetlands. Smooth cordgrass (*Spartina alterniflora*) is the dominant species of the Georgia wetlands and occurs in two distinct forms.

Creekbanks, which occupy less than 10 per cent of the total area, are dominated by plants up to two meters tall. More extensive back marsh areas are colonized by a short form of smooth cordgrass. Salinity may become very high in areas that are infrequently flooded and where evapotranspiration is very high. In those situations smooth cordgrass is eliminated and only salt-tolerant species such as glassworts (*Salicornia sp.*) occur. Salt flats have soil salinities that are at times more than double that of sea water and no vascular plants can survive there.

While the same processes and overall patterns of plant distribution occur in the Maryland portion of the Chesapeake Bay, these wetlands are very different from the coastal lagoonal areas of Georgia. The State of Maryland has recognized 35 different types of wetlands ranging from freshwater tidal wetlands, that are restricted to areas near the head of tide in the major river systems, to the more saline wetlands dominated by tall and short forms of smooth cordgrass. Where freshwater conditions persist, plants tolerant of intermediate salinity are replaced by species of freshwater wetlands. Botanical similarities are, however, non-existent as the freshwater areas are dominated by completely different plant species. Whereas only a few species of plant dominate the brackish wetlands and most of them are grasses, freshwater tidal wetlands have numerous plant forms and species. Spatterdock (*Nuphar advena*) occurs in shallow stream beds and shallow ponds. The erect leaves of arrowarum (*Peltandra virginica*) pickerelweed (*Pontederia cordata*) and arrowhead (*Sagittaria sp.*) are common on the levees and high marsh.

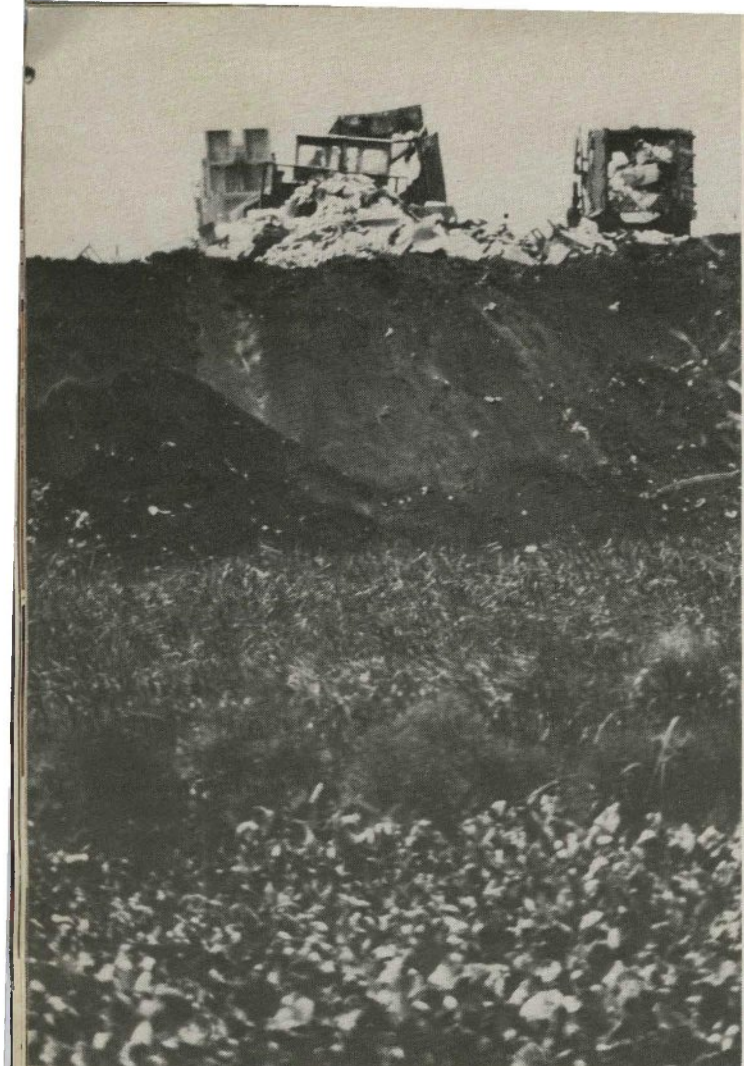
Perhaps the most interesting feature of these wetlands is the constantly changing seasonal appearance. In the early part of the growing season the wetlands are covered with various shades of green due to the dominance of plants including cattail (*Typha sp.*), sweet flag (*Acoru calamus*), and arrowarum. In mid-summer vast areas are often awash in the light yellow to the greenish tones of wild rice (*Zizania aquatica*) and blues to purples of swamp loosestrife (*Lythrum salicaria*), pickerelweed, and marsh mallow (*Hibiscus sp.*).

By September the wetland is resplendent in the yellows of the flower of bur marigold (*Bidens laevis*). Autumn is marked by browns as the vegetation withers, although the whites of the flowers of arrowhead and purples of pickerelweed remain until the first killing frosts. By late autumn, much of the vegetation has decomposed and by late winter much of the wetland surface is barren because of the very high rates of decomposition. In that respect the freshwater tidal wetlands are very different from the brackish and saline wetlands which are characterized by a persistent deep layer of plant litter owing to slower rates of decomposition.

Between the freshwater tidal wetlands and the coastal salt marshes are large areas of intermediate salinity wetlands. Streamside levees are poorly developed because of small tidal range and smooth cordgrass may only be a minor member of the plant community. Other species such as marsh elder (*Iva frutescens*) and switchgrass (*Panicum virgatum*) co-exist with smooth cordgrass on the levee. In Georgia these two species only occur near the border between wetland and the upland where tidal flooding is infrequent and where there would be freshwater runoff from the upland. Chesapeake Bay brackish wetlands in Maryland have less short smooth cordgrass (10,150 hectares) than brackish high marshes dominated by saltmeadow hay (*Spartina patens*) and spikegrass (*Distichlis*

Ditching is used to eliminate mosquitoes; (left) parallel ditching used in the 1930s and 1940s was not effective as it was not distributed across the entire wetland surface. (Right) a rotary ditcher is used in effecting a process called 'open marsh water management' (above), so that extensive ditching will eliminate mosquitoes

(Below left) mosquito control depends on a dry substrate. In 'open water marsh management' the ditches drain the marsh with each tidal cycle. (Below right) within two growing seasons vegetation recovery was dramatic in areas where the ground was drained, thus lowering the water-table. Mosquito control was achieved without the use of pesticides



Many of the wetlands have been converted into uplands by the dumping of refuse (left). Most of these landfills are now being reclaimed – as wetlands

An experimental area in the Hamilton Marshes is used to determine if freshwater tidal wetlands can perform the final treatment of partly-treated municipal wastewater. It is sprinkled on at high tide so that nutrients will be absorbed by the marsh (below)

spicata) – 12,574 hectares – and areas dominated by needlerush (*Juncus roemerianus*) – 19,701 hectares.

Irregularly flooded brackish high marshes contain numerous depressions that are sites for intense mosquito breeding and are the focus of extensive management activities. Water level in the depression varies and mosquitoes lay eggs on the exposed substrate when water levels drop. The eggs remain dormant until the next flood, caused either by tides or precipitation, when they hatch. Earlier this century many coastal areas were ditched to drain the wetlands and thus eliminate mosquito breeding habitats. Parallel ditching, however, did not reduce the mosquito problem. Most depressions were unaffected by the ditching because they are distributed across the entire wetland surface.

In recent years management agencies shifted to the use of chemicals that killed either adult or larval mosquitoes. However the cost of that type of control has proven to be excessive and mosquitoes have developed resistance to the chemicals. In addition, there was also concern that the chemicals were killing 'non-target' species that are important in estuarine food webs. More recently priority has shifted to ditching again in an attempt to manage only those areas in the wetland that breed large numbers of mosquitoes.

Several coastal states use a process called open marsh water management which involves extensive ditching to connect and/or eliminate all of the depressions on the wetland. Experimental studies of that technique and modifications of it have been conducted in New Jersey, Maryland, and Delaware in the past few years and they have proven effective in eliminating mosquitoes under most circumstances. The procedure has been particularly effective in coastal wetlands that are dominated by either tall or short forms of smooth cordgrass. In wetlands dominated by saltmeadow hay and spikegrass the technique has been successfully used to eliminate mosquitoes but undesirable changes have also occurred. When ditched areas were coupled to the estuary to permit tidal flushing the wetlands were colonized by undesirable shrubs such as sea myrtle (*Baccharis halinifolia*) and marsh elder (*Iva frutscens*). The resultant changes in vegetation of the wetland produced unacceptable losses such as habitat for waterfowl, muskrats, and other animals. Mosquito control then, while not destroying the wetlands, is a question of enormous economic and social importance.

Other activities affect wetlands detrimentally. Dredging and filling of Atlantic Coast wetlands has almost been eliminated because of strong state and federal laws protecting wetlands. The practice of converting wetlands into uplands by dumping tonnes of solid waste refuse has been slowed in most areas and some uplands are even being reclaimed as wetlands.

During the past decade there has also been a movement to use wetlands as a medium for treating sewage in the United States. The cost of secondary treatment plants has proven beyond the means of most local governments and construction funds from the federal government have almost stopped. In addition rivers and streams near towns have been heavily affected by pollutants from many sources such as sewage plants and runoff from agricultural land. Some people believe that wetlands can be effectively used to provide additional wastewater treatment due to their natural ability to assimilate nutrients from water.

Experimental projects have been conducted in several types of wetland systems with mixed results. Salt marshes in Massachusetts have been shown to be capable of assimilating nutrients and heavy metals from sewage sludge without any long-term detrimental effects, but it seems unlikely that they can be used for treating large quantities of municipal wastewater. Cypress wetlands in Florida can efficiently process and store nutrients when wastewater is applied in small amounts.

Freshwater tidal wetlands have also been studied and it may be possible to use them for 'wastewater polishing' but they appear to be capable only of treating wastewater during the months when plants are growing. Perhaps most exciting has been the realization that artificial wetlands can be created which can be designed to treat wastewater from municipal and industrial sources. This technology, used for years in Europe, is now being considered by regulatory agencies and municipalities in the eastern states.

A little more than a decade ago, the future of wetlands did not seem very optimistic. Now, however, they have been shown to be important and organizations from local groups, that identify and oversee local wetland sites, to large national organizations are involved in the process of wetland preservation and protection. The USA's wetland resources are of enormous value and as part of its environment heritage are worth passing on to future generations in good condition.

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