Wilson Bull., 103(2), 1991, pp. 218–254

APPROACHES TO THE CONSERVATION OF COASTAL WETLANDS IN THE WESTERN HEMISPHERE[1]

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ABSTRACT.—Coastal wetlands rank among the most productive and ecologically valuable natural ecosystems on Earth. Unfortunately, they are also some of the most disturbed. Because they are productive and can serve as transportation arteries, coastal wetlands have long attracted human settlement. More than half of the U.S. population currently lives within 80 km of its coasts, and one estimate places 70% of all humanity in the coastal zone. Human impacts to coastal wetlands include physical alteration of hydrological processes; the introduction of toxic materials, nutrients, heat, and exotic species; and the unsustainable harvest of native species. Between 1950 and 1970, coastal wetland losses in the U.S. averaged 8100 ha/year. In Central and South America, development pressures along the coastal zone rank among the most serious natural resource problems in the region.

Here, we (1) briefly describe coastal wetland avifauna, (2) discuss the threat of global warming on coastal wetlands, (3) use several Western Hemisphere wetlands as site-specific examples of development pressures facing these habitats, and (4) provide synopses of non-governmental and governmental approaches to wetland conservation. Overall, we provide a socio-economic context for conservation of coastal wetlands in the Western Hemisphere. We suggest that efforts aimed at conserving sites of particular importance for their biological diversity should be pursued within a framework of wise use that addresses the broader issues of human population growth and economic development.

"*Ere long marshes will be looked upon by mankind as gifts from heaven to prolong the life and happiness of the greatest portion of the animal kingdom*" (A. Seybert 1799).

Coastal wetlands include seasonal and relatively permanent coastal-plain freshwater swamps and marshes, coastal beaches, rocky shorelines, estuarine salt marshes, mangrove swamps, seagrass beds, mud flats, oyster reefs, and sand bars (Figs. 1 and 2). Such habitats are usually characterized

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FIG. 1. Aerial view of a typical cordgrass (*Spartina alterniflora*) salt-marsh estuary (the North Inlet Estuary) near Georgetown, South Carolina.

as low-lying lands in which the water table is at or near the surface on a regular, albeit sometimes intermittent, basis. The Convention on "Wetlands of International Importance Especially as Waterfowl Habitat"—the so-called "Rasmar Convention"—broadly defines coastal wetlands to include ". . . areas of marine water the depth of which at low tide does not exceed six metres," (Ramsar, Article 2; Lyster 1985). Many authorities, however, include permanently flooded areas in their definition of coastal wetlands only when such sites contain emergent vegetation (Arthington and Hegerl 1988). Despite considerable variation within and among sites (Day et al. 1989), coastal wetlands, especially estuaries, rank among the most productive and ecologically valuable natural habitats on Earth (Whittaker and Likens 1971, Odum 1978).

Because of their primary and, especially, secondary productivity, as well as their value as transportation arteries, coastal wetlands have been attractive sites for human settlement for thousands of years. Many of the prominent "cradles of civilization" developed in and, initially, thrived around the coastal estuaries of the Middle East, India, and China. In California, "maritime-dependent" human settlements date from the second millennium B. C. On the East Coast of North America, fish weirs dating from 1700 B. C. have been excavated in what is now Boston, Massachusetts (Siry 1984). In most instances, developing centers of hu-

FIG. 2. The Caroni Swamp, Trinidad, West Indies. This 5600-ha mangrove swamp was once the only breeding site of Scarlet Ibises (*Eudocimus ruber*) in Trinidad.

man population substantially modified their wetland habitats. Archaeological excavations in central Greece reveal that the draining of Lake Copais dates from the 25th Century B. C. (Despite the later apocryphal attempts of Hercules to reflood the area, this 20,000-ha lake site remains completely drained [Heliotis 1988].) Similar anecdotes abound for the more recently settled Western Hemisphere, where for example, in the late 18th Century, three of the founding fathers (G. Washington, T. Jefferson, and P. Henry) of the then fledgling United States suggested draining the Great Dismal Swamp in coastal Virginia (Hair 1988).

Humanity continues to concentrate its population centers in coastal regions. In New York for example, where the statewide population averages 351 people/mile^2, density increases to more than 5000 people/mile^2 in coastal counties (Simon 1978). Currently, 52% of the U.S. population lives within 80 km of the U.S. coast (Southworth 1989); worldwide, many of our largest cities are in coastal areas (Day et al. 1989), and some estimates place 70% of the world's human population along sea coasts (cf. Cherfas 1990). As humanity continues to grow and settle in such sites, coastal wetlands face an increasingly perilous future. Humans impact coastal wetlands directly through (1) physical alteration, (2) the introduction of toxic materials, (3) enrichment with excessive levels of naturally occurring materials (including nutrients) and heat, and (4) the harvesting of native species and the introduction of exotic species (Day et al. 1989). Potential indirect, and certainly more difficult to document, effects include saltwater intrusion and increased flooding as a result of water-use systems, channelization, and global sealevel rise (Abrahamson 1989, Lester and Myers 1989).

As a result of human impacts, many coastal wetlands in the Western Hemisphere have already been lost. Tiner (1984) suggests that only 46% of the original wetland acreage in the U.S. remains. Although most U.S. wetland losses have occurred in noncoastal sites, the loss of coastal wetlands between 1950 and 1970 is reported to have averaged 8100 ha/year (Frayer et al. 1983). Other estimates (Gagliano et al. 1981, Hefner and Brown 1985) suggest even greater declines, with the southeastern U.S. losing 7% of its coastal wetlands—mainly salt marshes—over the same two decades. Speth (1979) suggests that within the last 100 years, 70% of California's intertidal wetlands have been altered by humans.

In Latin America and in the Caribbean Basin, pressures along the coastal zone currently are among the most serious problems facing natural resource management in the region. In the face of extraordinary external debt, rising populations, and widespread poverty, governments are attempting to expand agricultural and industrial production, while local inhabitants are using resources even more intensively to meet daily needs. A recent compilation of neotropical wetlands of international importance within the context of the Ramsar Convention (Scott and Carbonell 1986) reports that almost 20% of these wetlands are threatened with draining for agricultural purposes (Maltby 1988). Unfortunately, only four of the 44 countries in the region, representing less than 20% of all neotropical wetlands, are contracting parties of the Ramsar Convention (Smart 1989, Schlatter 1989).

Recent international attempts to stem the tide of wetland loss are highlighted by (1) "The Convention on Wetlands of International Importance Especially as Waterfowl Habitat," which in 1971 became the first of four recent international treaties that currently form the basis of international wildlife law (cf. Lyster 1985); (2) the inauguration in 1985 by the International Union for Conservation of Nature and Natural Resources of a global campaign to preserve wetlands; (3) a United Nations declaration making 1986 the International Year for Wetland Conservation; and (4) the establishment of the North American Waterfowl Management Plan and the Western Hemisphere Shorebird Reserve Network.

In this report, we do not attempt to provide a thorough overview of the status and conservation of coastal wetlands in the Western Hemisphere; we leave that to more lengthy and detailed treatments of the subject (e.g., Alexander and Broutman 1986, Scott and Carbonell 1986, Feierabend and Zelazny 1987, Zelazny and Feierabend 1988, Pannier and Dickinson 1989). Instead, we focus on several issues of concern with which we are familiar, especially as they affect the birds that inhabit these environments. Specifically, after briefly describing coastal wetland avifauna, we (1) discuss the encroaching threat of global warming on coastal wetlands and their avifauna, (2) use the Florida Everglades, the Arctic coastal plain of Alaska, and coastal wetlands in Central and South America as site-specific case studies to indicate the complexities, both biological and sociological, that face wetland conservationists, and (3) provide synopses of the Western Hemisphere Shorebird Reserve Network, the North American Waterfowl Management Plan, and government programs in the U.S. as examples of private and Federal approaches to wetland conservation.

For additional information, or to offer suggestions on any of the topics discussed herein, please contact the principal author(s) of each section: Introduction and Coastal Wetland Avifauna (Bildstein), Global Warming (Nol), Florida Everglades (Bancroft), Arctic Coastal Plain (Senner), Central and South American Coastal Wetlands (Dugan and Bildstein), Western Hemisphere Shorebird Reserve Network (Payne), North American Waterfowl Management Plan (Gordon), and U.S. Government Programs (Erwin).

COASTAL WETLAND AVIFAUNA

Less than 3% of the Western Hemisphere land surface consists of coastal wetlands. Estuarine wetlands are even less common, comprising, for example, only 0.3% of the land surface of the lower 48 states (Tiner 1984). Even so, these habitats are characterized by both high densities of birds and considerable species richness. Typically, coastal wetland avifauna is dominated, at least numerically, by large numbers of Anseriforms (waterfowl), Ciconiiforms (long-legged wading birds), and Charadriiforms (shorebirds, gulls, and terns) (e.g., Bildstein et al. 1982, Hicklin 1987). At many sites avian populations increase considerably, not only during migratory periods, when large numbers of waterfowl and shorebirds congregate to feed and rest in such areas, but also during the breeding season, when wading birds congregate at traditional coastal-colony nesting sites. Consequently, many coastal wetlands in the Western Hemisphere annually host significant (sensu the Ramsar Convention) portions of the world populations of a number of species (Myers et al. 1987).

For example, more than half of the Mississippi Flyway population of migratory waterfowl concentrates in wetlands along the U.S. portion of the Gulf of Mexico each winter (Southworth 1989). Between 42 and 74% of all Semipalmated Sandpipers (*Calidris pusilla*) stop to feed at a few sites along the Bay of Fundy in maritime Canada each fall (Hicklin 1987), and then move on to winter in coastal Suriname (Morrison and Myers 1987, Morrison and Ross 1989). Similarly, migrating and overwintering

Western Sandpipers (*C. mauri*) and Dunlins (*C. alpina*) assemble at a series of estuarine sites along the Pacific Coast each year (Morrison and Myers 1987). Twenty-six species of colonial waterbirds numbering more than 874,000 birds nest in coastal Louisiana, Alabama, and Mississippi alone (Portnoy 1977). More than 290 colonies of wading birds, some in excess of 40,000 birds each, occur along the east coast of the U.S. (Osborn and Custer 1978). Similarly, enormous assemblages of wading birds and shorebirds are reported for wetlands along the Atlantic coast of South America (Spaans and de Jong 1982, Morrison and Ross 1989).

Coastal wetlands sites can also be rich in numbers of species. In North America, for example, 25% of the 374 species of birds on the South Carolina state list (Post and Gauthreaux 1989) are reported from a single 3000-ha salt-marsh in the state (Bildstein et al. 1982). And in Trinidad, 39% of the 400 species of birds reported for the 4828-km^2 island have been sighted at a single 5600-ha coastal mangrove swamp (ffrench 1978, 1980).

THE POTENTIAL EFFECT OF SEA LEVEL RISE ON NESTING COASTAL-WETLAND AVIFAUNA

Although meteorologists have been hesitant to ascribe causes to global warming (Jones and Wigley 1990), a wide range of climate models have established that global temperatures have been rising over the last 100 years (Kuo et al. 1990). As a consequence, sea levels may rise by as much as 5 mm yr^{-1} (or approximately 0.3 m by the year 2050), as opposed to current increases of about 2 mm yr^{-1} (Meier 1990, but see Titus [1988: 8] for more conservative estimates). Many coastal birds nest on the ground or in floating wrack, where their nests, eggs, and nestlings are often flooded (McNicholl 1985). Rising sea levels are likely to result in more frequent flooding and possibly the complete loss of habitat for some of these birds.

Numerous factors determine the effect of high water levels on the reproductive success of coastal birds. Some are extrinsic and depend on the resiliency of the habitats to rising water levels; others are intrinsic and depend on life history characteristics of the birds.

Extrinsic Factors

Beaches and dunes.—Beaches and dunes differ in their resiliencies to rising water levels. Beaches are formed by the accumulation of sands from wave action (Smith 1990). Higher water levels will cut away beaches, leaving only high-dune vegetation. High waves, which are predicted to accompany global warming, will flatten dunes and result in fewer beaches. Most likely, new beaches will form in developed areas, where attempts will be made to restrain waves with breakwaters and other means. Hence, the amount of beach habitat will almost certainly decline. As artificial barriers are notoriously ineffective, human development will eventually be forced inland, and eventually, beach areas should return through natural processes. Whether birds will colonize those areas will depend on the sustained availability of source populations.

Some barrier islands may migrate landward as sea levels rise. However, others will probably break up and disintegrate (cf. Titus 1988). Beach nesters using such sites (e.g., Royal Terns [*Sterna maxima*], Black Skimmers [*Rynchops niger*], Piping Plovers [*Charadrius melodus*], and Wilson's Plovers [*C. wilsonia*]) may decrease in numbers.

Salt marshes.—Salt marshes are complex ecosystems that depend on the accumulation of organic matter and mineral deposits for their formation (Smith 1990). Low-marsh vegetation, such as salt-marsh cordgrass (*Spartina alterniflora*), is well adapted to living in inundated areas, and the range of this habitat type may extend gradually inland, but only if acceleration in sea level rise is slight. Should the rate of sea level rise exceed that at which cordgrass marshes can accrete sediment and grow upward (i.e., approximately 4–6 mm/yr), substantial losses of this habitat type will occur (Titus 1988). High-marsh vegetation such as salt-marsh hay (*Spartina patens*), spikegrass (*Distichlis spicata*), and salt-marsh shrubs (e.g., *Iva frutescens* and *Baccharis halimifolia*), which is less tolerant of saltwater intrusion, is even more likely to decline. Thus, while populations of birds nesting on cordgrass or detrital wrack (e.g., Clapper Rails [*Rallus longirostris*], Laughing Gulls [*Larus atricilla*], Common Terns [*Sterna hirundo*], Forster's Terns [*S. forsteri*], Black Skimmers, Willets [*Catoptrophorus semipalmatus*]), may remain stable, or decrease only slightly; those of many wading birds nesting in high-marsh vegetation (e.g., some, but not all populations of herons, egrets, and ibises), are more likely to be reduced.

Weather.—Several models suggest more extreme weather patterns, including an increase in the number and severity of coastal storms, typhoons, and hurricanes (Emanuel 1987, Overpeck et al. 1990). Along the east coast of North America, the impact of high spring tides (those most frequently inundating nest sites) is greatly dampened by strong westerly winds that blow water from nest areas, and is intensified by strong easterly winds that blow water toward and over nesting areas. If land temperatures continue to rise, coastal areas can expect stronger onshore winds, which will exacerbate flooding problems for species nesting in either salt marshes or near the high-tide line on beaches (Meier 1990).

Intrinsic Factors

Site-fidelity patterns.—At least some coastal nesters are extremely site tenacious (e.g., Clapper Rail, Meanley 1985; Wilson's Plover, Bergstrom

1988; American Oystercatcher [*Haematopus palliatus*], Nol 1985; Willet, Howe 1982; and; possibly, Royal Tern), while others are not (e.g., Forster's and Common terns, Erwin et al. 1981; Black Skimmer, Erwin et al. 1981, Burger, 1982). Some species are facultative (e.g., Piping Plover, Haig and Oring 1988; Least Tern, Burger 1984, Kotliar and Burger 1986, Atwood and Massey 1988; White Ibis, Frederick 1987). Site fidelity should be inversely related to variance in reproductive success, which is probably related to habitat stability (McNicholl 1975). If site fidelity is genetically inflexible, then any change in habitat will spell disaster for a species. Thus, species already living in unstable habitats are likely to cope best with sea-level increases.

Habitat use.—Habitat selection and site tenacity are often closely linked. Even so, some species are extremely habitat specific but not site-tenacious (e.g., Piping Plovers, Haig and Oring 1988). For some birds, flexibility in the choice of nesting habitats could be the key to surviving increased water levels. Consider, for example Piping Plover and Killdeer (*C. vociferus*): the former is relatively inflexible in its choice of habitats, nesting nearly always on pebbled beaches on the ocean or large lakes. The beach must be clear of visual obstructions and the nests are often quite close to the high tide mark (Burger 1987). The endangered status of this species (Sidle 1985) is due, at least in part, to this inflexibility. By contrast, Killdeers nest in many human-altered habitats, sometimes at considerable distances from water, have a broad geographic range, and are expanding into northern Canada (Nol and Lambert 1984, E. Nol pers. obs.). Similarly, American Oystercatchers, Common Terns, and Laughing Gulls nesting in coastal New York and New Jersey, are flexible in nest-site selection, having moved onto wrack and dredge-spoil islands (Montevecchi 1978, Burger and Shisler 1980, Burger 1985, Lauro and Burger 1989), presumably in response to increasing human use of traditional nesting areas. Black Skimmers appear to show geographic variation in habitat selection (Gochfeld 1978; Burger 1982, 1985); some populations of Least Terns nest on roof-tops (Massey 1974), an advantageous habitat in a period of higher sea levels.

Longevity.—Most of the species considered here have high rates of adult survival (Hickey 1952). Some, such as the American Oystercatcher, are able to maintain stable, or even increasing populations, despite poor reproductive success, for up to four years (Nol 1989). Population models suggest that this is true only if annual survivorship is greater than 80%. Repeated annual losses due to high tides will be of greater consequence to species with lower rates of annual survival.

Timing of nesting.—Species with combined laying and incubation periods of less than 28 days (the time between successive spring-tide sets) can increase their reproductive success, but only if nests are initiated immediately after a spring tide set. For example, American Oystercatchers lose most of their nests to high spring tides when peak laying is delayed until during or after the low neap tides that follow high spring tides by about one week. In species such as Clapper Rails, Piping Plovers, Wilson's Plovers, and Royal Terns, which have relatively long laying and incubation periods (all >30 d) (Meanley 1985, Wilcox 1959, Bergstrom 1988, Erwin et al. 1981, respectively), nests are exposed to two high spring tides, and reproductive success depends heavily on extrinsic factors such as weather. Increases in the severity and frequency of storms will narrow the window of safe nesting for these species. Indeed, the most serious impact of global warming on coastal-nesting birds will probably come from significant increases in onshore winds and storms.

Population projections.—Assuming that the projected rates of sea-level rise indicated above are correct, one tentative population model (E. Nol, unpubl. ms) predicts that numbers of American Oystercatchers, Piping Plovers, Wilson's Plovers, Least Terns, and Black Skimmers will decrease, while Clapper Rail, Laughing Gulls, and Common and Forster's terns, will remain stable or increase.

CASE STUDIES

The Florida Everglades and Associated Estuaries

Although no single case study could possibly be considered typical or representative of all of the issues involved in wetland conservation, the story of the Florida Everglades and associated estuaries illustrates the magnitude of some of the problems facing wetland habitat conservation efforts, especially in the developed Neotropics.

The Everglades is the largest wetland system in south Florida. Historically, the Everglades was a vast seasonally flooded wetland that extended from Lake Okeechobee south to the Gulf of Mexico (Fig. 3). This wetland system, which originally covered 9900 km^2, was made up of a mosaic of sawgrass (*Cladium jamaicense*) marshes, spike rush (*Eleocharis celulosa*) sloughs, and tree islands (Parker 1974). The Everglades was bordered on the east and west by the Coastal Ridge and Big Cypress swamp, respectively. Along the southern and southwestern border, the freshwater Everglades joined with a brackish mangrove-estuarine belt along the coast.

Seasonal rainfall is the dominant environmental variable driving wetland ecology in South Florida (Bancroft 1989). More than 80% of the annual rainfall ($\bar{x}$ = 1357 ± 259 [SD] mm, N = 25 years) occurs in a six-month period from mid-May through mid-November. Water levels rise in freshwater marshes during the rainy season and recede during the dry season, influencing the volume of water that flows into the estuaries.

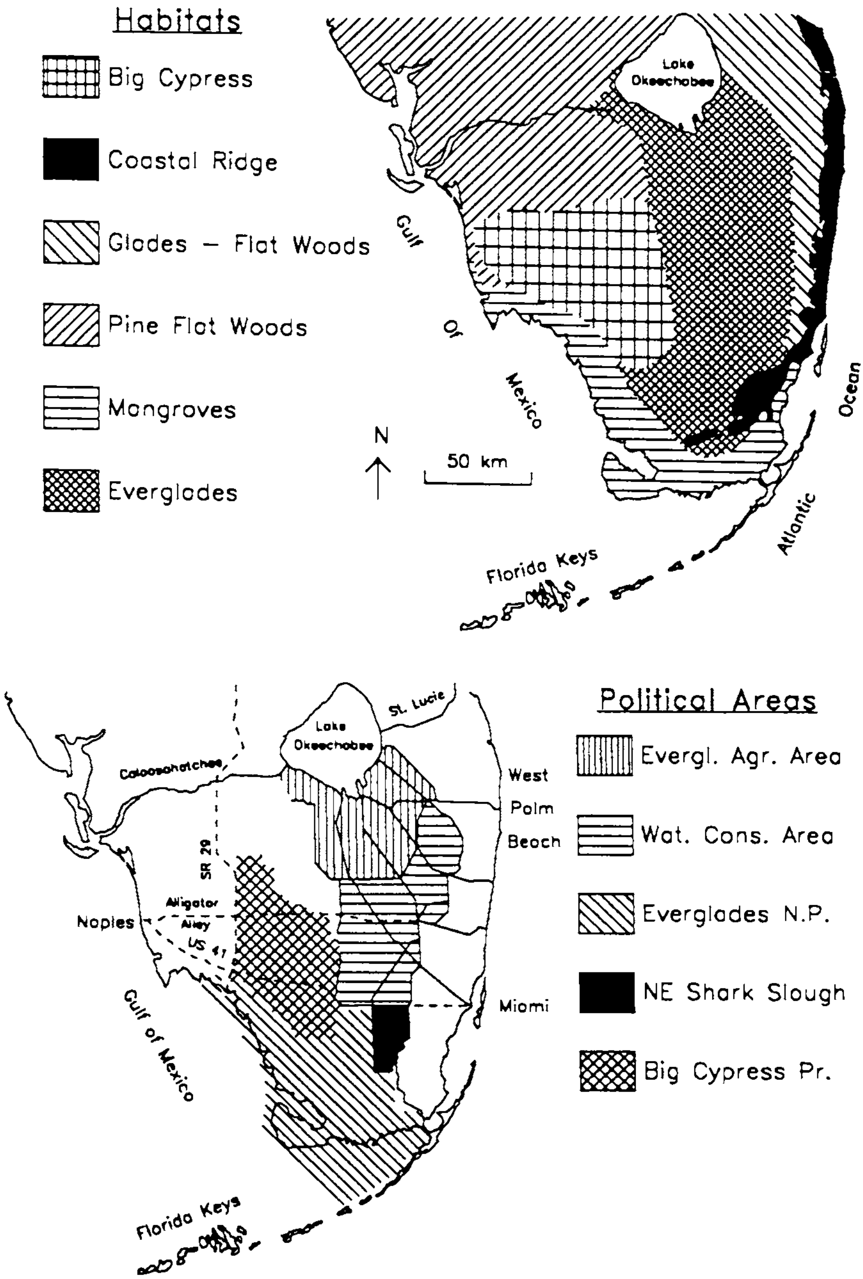

FIG. 3. The habitats of south Florida before humans began to drain the wetlands (top), and current geographic areas (bottom). Canals are shown by solid lines, roads by dashed lines.

Historically, at the height of the rainy season, the Everglades was flooded by a shallow sheet of water up to 65 km wide that flowed slowly south at less than 200 m/day (Leach et al. 1972). Water levels receded gradually during the dry season, usually reaching an annual low in May. Because of small variations in topography, isolated pools formed as water receded. These pools trapped and concentrated aquatic animals from the marshes, and large numbers of wading birds moved into the Everglades system to feed on the trapped and concentrated prey (Kushlan 1976). Wading birds nested colonially in huge numbers along the southwest edge of the system where the freshwater Everglades intertwine with coastal mangroves (Robertson and Kushlan 1974, Kushlan and Frohring 1986, Ogden 1978). Ogden (in press) estimated that, in good nesting years in the 1930s, some colonies may have contained 125,000 to 150,000 nesting pairs of wading birds.

Development of the infrastructure for water management.—The Everglades that once supported large concentrations of nesting wading birds has been modified by humans. Changes include drainage and conversion to agriculture, alteration of hydroperiods, adjustments in flow patterns, increases in nutrient and heavy-metal loading, and invasion by exotics. All of these changes have compromised the capacity of the Everglades to support large numbers of breeding wading birds.

Beginning in the late 1800s, considerable effort was invested in draining the marshes. By the early 1960s, more than 2200 km of canals and levees had been constructed (Light et al. 1989). Canals drained the northern third of the original Everglades, creating the Everglades Agricultural Area (3100 km^2; Fig. 3). The central third remains as marsh but the area is surrounded and crossed by a series of canals and levees, which form five Water Conservation Areas (WCAs) of 3400 km^2 (Fig. 3) (Tebeau 1974). Each area is managed to provide flood protection, water storage, and wildlife habitat. The southern section of the original Everglades includes Everglades National Park and an overdrained marsh east of the park known as Northeast Shark Slough (Fig. 3).

The drainage network was altered throughout the system. Flood protection for agricultural areas requires rapid removal of rainfall, resulting in unnaturally large pulses of water entering the marshes. Canals within the WCAs drain the northern sections of each area, and increase hydroperiods in southern sections of the areas.

With the completion of water control structures in 1962, water flow from the WCAs into Everglades National Park became highly regulated (Light et al. 1989). Overland flow entered the Park through four points along US highway 41, and as sheet flow across its eastern border from Northeast Shark Slough (Fig. 4). In 1967 a canal was dug along the eastern

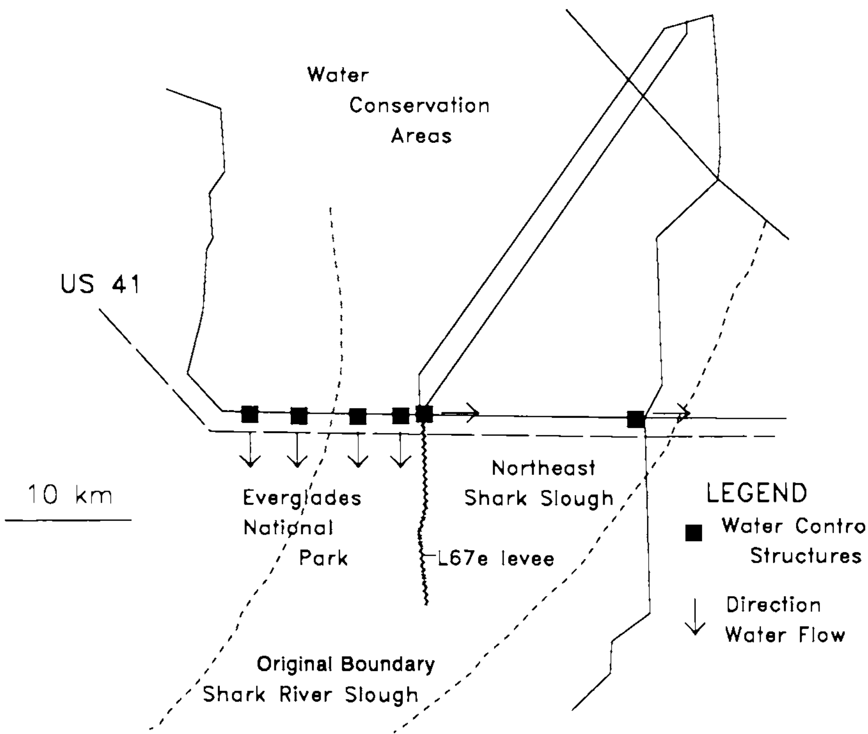

FIG. 4. Water control structures at the interface between Water Conservation Area 3 and Everglades National Park.

border of the Park immediately south of WCA 3. This canal isolated the Northeast Shark Slough, thereby changing the pattern of flow into the Park. Starting in 1962 and continuing for two years, the flow was stopped entirely. The resulting drought in the Park brought national attention to water management in the Everglades. A public outcry resulted in Federal legislation that mandated minimum monthly water delivery to the Park. This prescription, however, allowed extra regulatory releases of water to occur at the discretion of water managers.

The quality of water entering the Everglades from adjacent agricultural areas also has declined. Phosphorus and nitrogen loads are higher than occurred in the historical marsh (Davis 1989). Added nutrients have changed the periphyton community and caused a shift from a community dominated by sawgrass to one dominated by cattails (*Typha domingensis*). Both changes have decreased the value of these areas to wildlife, and in particular, their use by wading birds (Bancroft, unpubl. data). Mercury contamination has also become a problem in the Everglades, where it accumulates in higher trophic levels and may increase mortality for top predators such as wading birds and eagles. The source of this contaminant is not known, but mercury has recently been found throughout the WCAs and the Park. One source may be naturally occurring mercury compounds found in peat soils. Peat soils are being oxidized in agricultural areas because the water table is drawn below the surface. Oxidation releases mercury, which is then washed through the system by rain.

Exotic plants and animals also threaten the restoration effort. One of the most serious exotics is cajeput (*Melaleuca quinquenervia*) which, because of its extremely high transpiration rates, was introduced into south Florida to help drain the Everglades.. This exotic, which is spreading through the Everglades, occurs in dense stands, providing poor foraging habitat for wading birds (Schomer and Drew 1982). Development of effective control measures for this plant is essential if the system is to be restored and maintained.

Effects of water management on wading birds.—Current and past water manipulations in the Everglades have resulted in decreased breeding populations of wading birds, shifts in colony sites, and a general delay in the timing of nesting. Since the 1930s, nesting populations have decreased for all species of wading birds (Bancroft 1989; Ogden, in press). More than 100,000 pairs of White Ibises (*Eudocimus albus*) attempted to nest during several years in the 1930s. During the 1970s, the maximum number attempting to nest in any year was 24,500 pairs in 1972 (Frederick and Collopy 1989). During the late 1980s, nesting efforts continued to decline, with a maximum of just over 10,000 pairs attempting to nest in 1988 (Bancroft 1989). Wood Storks (*Mycteria americana*) show similar decreases in nesting effort (Ogden and Nesbitt 1979; Ogden et al. 1987; Kushlan and Frohring 1986; Ogden, in press). The mean number of pairs attempting to nest in the 1980s was only 400, compared with 700 in the 1970s, and 1800 in the 1960s (Bancroft 1989). Nesting efforts of Great Egrets (*Casmerodius albus*), Snowy Egrets (*Egretta thula*), and Tricolored Herons (*E. tricolor*) also have decreased, although less dramatically (Bancroft 1989; Ogden, in press).

During the 1930s, most wading birds in the Everglades nested along the freshwater-mangrove interface at the southern edge of the system. Nesting birds then had the option of feeding in freshwater marshes or in brackish-water estuaries and mangroves. By the 1970s, the center of nesting for Great Egrets, Tricolored Herons, and White Ibises had shifted north out of Everglades National Park and into the Water Conservation Areas (Frederick and Collopy 1989, Bancroft 1989). Because available foraging habitat is less diverse in the Water Conservation Areas than it is along the marsh-mangrove interface, wading birds nesting in the WCAs may be less resilient to water-level reversals caused by rainfall or water management than are birds nesting along the mangrove fringe (Bancroft et al. in press).

The onset of wading-bird colony formation has been delayed in recent decades. For example, in 14 of 16 years before 1970, Wood Storks in the Park began nesting in November and December; since 1970, storks have begun nesting after 1 January in 19 of 21 years ($G = 25.3$, df $= 1$, $P < 0.001$) (Ogden, in press). This temporal shift is correlated with the construction of canal L67e along the eastern border of the Park (Fig. 4) and the implementation of the minimal water delivery schedule (Ogden, in press). Few data are available for other species, but they too suggest a delay in the onset of nesting that might make it difficult for birds to complete nesting before summer rains begin. Summer rains cause water levels to rise, dispersing prey and causing problems for birds attempting to raise young (Frederick and Collopy 1989).

Recent hydrologic modeling of the Everglades strongly suggests that water management has decreased the flow of water to the estuaries (C. Walters, L. Gunderson, and C. S. Hollings, pers. comm.). Upstream water is being diverted to the Atlantic Ocean for flood protection, stored in the WCAs for later use, or used to recharge aquifers for municipal and agricultural uses. Lower freshwater flow, especially late in the dry season, may have reduced the primary productivity at the mangrove-freshwater interface (C. Walters et al., pers. comm.), which may have contributed to the major decrease in the breeding numbers of wading birds as well as to the shift in nesting locations.

Recommendations for the Everglades system.—By 1980 it was clear that water management was causing longterm degradation of the Everglades ecosystem and the modification was needed. Both the quantity and quality of water, as well as the timing of its flow, need to simulate a more natural system. Producing such patterns requires the cooperation of numerous governmental agencies.

The availability and use of water should be a major consideration in the formulation of longterm development plans for south Florida. Water rights of the Everglades need to be addressed in these plans, perhaps even mandated by the Federal government. The formulation of an overall water budget for south Florida would help define current water uses. Water conservation programs should be implemented in both urban and agricultural areas. Unlimited water should not be made available for urban areas or agriculture.

Restoration of Everglades National Park will require the redistribution of water from the Water Conservation Areas to Northeast Shark Slough and into the Park. Congress has authorized the purchase of the Northeast Shark Slough area, and the addition of this property to the Park. Money, however, has not yet been appropriated. The levee and canal separating Northeast Shark Slough from the Park needs to be removed to allow more natural overland flow (Fig. 4). The levees and canals in the southern part of the Water Conservation Areas need to be modified structurally to allow a more natural distribution of water (Fig. 4).

Developing the appropriate management schedules for these structures will take time. Water released from the conservation areas into the Park needs to be regulated carefully, so as to simulate the natural system. The South Florida Water Management District has developed a "rainfall driven" plan to estimate the amount that should flow south. This model uses the water stored in the conservation areas plus the amount of rainfall over the previous two weeks to estimate how much water would have flowed into the park before development (MacVicar 1984). Some water from rainfall is allowed to flow south, while some is retained for storage (Walters et al., pers. comm.). This plan, which is a step in the right direction, will need to be modified as we learn more about the water budgets of south Florida and the quantities of water required in the estuaries.

Much of the land in south Florida is publicly held and, therefore, public management is at least in part responsible for maintenance of the environment. In spite of such "protection," the numbers of wading birds breeding within the Everglades system have decreased by 90% over the last 50 years. Upstream drainage and changes in the management of water flow within the natural marshes have disrupted the system. The Everglades, which will never again be total wilderness, needs to be regulated carefully if we wish to simulate the predevelopment function of this wetland.

The Arctic Coastal Plain of Alaska

Due in part to the hydrologic characteristics of permafrost, roughly half of Alaska's 155 million ha of land may be classified as wetlands. Much of that wetland acreage is coastal, including nearly all of the Arctic Coastal Plain.

The Arctic Coastal Plain includes the tundra wetlands of the North Slope and the wetlands and barrier islands of the Beaufort Sea coast, and provides valuable breeding habitats for millions of shorebirds (e.g., Semipalmated Sandpiper [*Calidris pusilla*]), waterfowl (e.g., eiders [*Somateria* spp.]), and loons (e.g., Yellow-billed Loon [*Gavia adamsii*], Derksen et al. 1981). Hundreds of thousands of postbreeding, molting, and migrating shorebirds and waterfowl (e.g., Red Phalarope [*Phalaropus fulicaria*], Snow Goose [*Chen caerulescens*]) also congregate at sites within the vast Arctic Coastal Plain (Connors et al. 1979, Garner and Reynolds 1986).

Most North Slope wetlands are intact, but subsequent to the discovery of oil in Prudhoe Bay, more than 8000 ha have been altered by the development and transportation of petroleum resources (R. G. B. Senner 1989). As virtually all of the region is legally designated as wetlands, the oil industry is chafing under the current regulatory framework, to say nothing of additional requirements that may be proposed as a result of the "no net loss" goal (see section on United States Government programs below).

In a recent report on behalf of the oil industry (ARCO Alaska and BP Exploration), R. G. B. Senner (1989) concludes that current industry practices adequately mitigate wetland losses on the North Slope and that no further regulation of wetland fills is necessary. Senner supports this conclusion "ecologically" by arguing that North Slope wetlands are less valuable than temperate wetlands and that Arctic-wetland species are not limited by habitat (i.e., wetlands are not at carrying capacity). Thus, incremental losses of wetlands do not now affect bird populations and, until population-level impacts are demonstrated, additional regulations are not justified.

In a critique of R. G. B. Senner (1989), on behalf of the Alaska Department of Fish and Game, Post (1990) reports that arctic-tundra wetlands share many characteristics with temperate wetlands, that they are reasonably productive, and that their preeminent value is as fish and wildlife habitat (Post 1990). Post concludes that migratory birds in the Arctic respond to their environment in the same way as do birds elsewhere, and that the availability of quality nesting habitats is of vital importance to avian populations.

Ultimately, issues of North Slope oil development will be resolved in political rather than technical forums. Recent political events in the Middle East have increased pressures to open areas such as the Arctic National Wildlife Refuge to oil exploration and development. This refuge is the only area on the North Slope owned by either the federal or state government that is in "protected" status. If it is developed, particularly in absence of a "no net loss" policy for wetlands (see section on U.S. Government Programs below), losses of tundra-wetland habitat due to the infrastructure (e.g., roads and gravel ponds) necessary for oil development will increase greatly.

Exploration and development of offshore sites in the Beaufort and Chukchi seas will increase the potential for oil spills in arctic marine environments, with serious implications for marine birds and wildlife in the addition to those relying on coastal wetlands. Depending on the location—for example, in the Chukchi Sea—offshore oil development also would mean additional pipelines and roadways across the North Slope feeding into the existing Trans-Alaska Pipeline, resulting in further loss of wetland habitat. Finally, transportation of oil via the Trans-Alaska Pipeline means that more oil will leave Valdez by marine tanker. Thus, accidents similar to the one that involved the Exxon Valdez in Prince William Sound can be expected to affect coastal waters, wetlands, and associated bird populations (e.g., Piatt et al. 1990) in the future.

Central and South American Coastal Wetlands

In this section we use examples to illustrate some of the problems facing coastal wetlands in Central and South America, and discuss possible solutions to these dilemmas. Taken as a whole, our examples reflect the site-specific nature of many of these problems, and the need to consider each situation individually. Although we highlight a number of geographic regions, we offer no coverage of wetland conservation in the southern, more temperate, zone of South America, where conservation problems *and* solutions may differ from those mentioned below.

The Neotropical Realm of Central and South America, including the Caribbean Basin, is both the most biologically diverse and one of the least disturbed of the world's eight biogeographical realms. Even so, many of the region's coastal wetlands are threatened by human disturbance (Scott and Carbonell 1986, Pannier and Dickinson 1989). Caribbean wetlands appear to be the most severely threatened, while some South American wetlands, many of which are little known, appear to be the least threatened; Central American wetlands fall in between. In large part, the severity of the threat is directly related to the density of the local human population (Scott and Carbonell 1986). The ecology of many Caribbean and Latin American wetlands remains little studied, although recent publications detailing the ecology, status, and conservation of some of these wetlands (Sarmiento 1984, Scott and Carbonell 1986, Pannier and Dickinson 1989) have narrowed the gap somewhat. Here we describe several examples of the problems facing these sites, together with current and proposed management schemes that extend beyond a single-species approach.

Mangroves.—Mangroves play a crucial role in the lives of local people over much of the Pacific Coast of Central America. These forested wetlands yield timber for construction, firewood, charcoal, and tannins, and, at the same time, support productive lagoonal and offshore fisheries (Pannier and Dickinson 1989). As economic conditions in the region have declined, many individuals have lost employment, and families have had to turn increasingly to natural ecosystems to find food and income. With the decline of the banana industry in southern Costa Rica, for example, many wage earners have begun to exploit mangrove resources, either through fishing or by harvesting mangrove for the production of charcoal and the extraction of tannins. In the absence of careful management, this rising pressure upon the resource is likely to lead to overexploitation and the gradual degradation of the resources upon which these people now depend.

In the face of this pressure, conservation efforts in several countries, most notably Costa Rica and Nicaragua, are turning away from strict protection and towards working with local people to assist them in the development and implementation of management activities that will enhance the sustainable use of the mangrove resource. In many cases where current use is not sustainable, programs are exploring ways to diversify the rural economy to increase income from other sources, thus reducing pressure on coastal wetlands. This approach not only meets rural development objectives, but, by reducing pressure on mangroves while simultaneously increasing support for mangrove conservation and management, also reduces the threat to these ecosystems posed by the growth of intensive agriculture, aquaculture, and industry.

Pesticide contamination in Nicaragua.—Pesticide levels in coastal wetlands along the Pacific Coast of Nicaragua are among the highest recorded in natural environments. Most pesticides are sprayed on cotton, which is grown along the coast. Although the use of DDT has been banned in Nicaragua since the early 1980s, many other toxic pesticides continue to be used.

Although current levels of contamination are primarily a cause of concern for public health, they also have longterm impacts on waterbird populations using these ecosystems. Accordingly, conservation efforts for Nicaragua's coastal wetlands must address not only the management of such sites, but also the broader issues of agricultural land use in the catchment. In the absence of this broader perspective, protected wetlands are likely to be seriously contaminated in the long term.

Saltwater intrusion in Trinidad's Caroni Swamp.—The Caroni Swamp is a 5611-ha mangrove-dominated coastal wetland in northwestern Trinidad, about 3.5 km southeast of the capital city of Port-of-Spain (Fig. 2). Although four rivers are associated with the estuary, most of the freshwater draining into the wetland comes from the Caroni River catchment of over 675 km^2. At least 157 of Trinidad's 400 species of birds use the swamp, including 18 species of wading birds, 14 of which reach their highest island populations there. Unfortunately, the Scarlet Ibis (*Eudocimus ruber*), Trinidad's national bird, a species that once bred in that country only in the Caroni, no longer does so. Ibises continue to feed and roost in the swamp outside of the breeding season, but during the breeding season, most adult ibises leave the island, presumably to nest in coastal South America (Bildstein 1990).

Numerous causes have been suggested for the cessation of Scarlet Ibis nesting at the site, but until recently none has been linked directly to the consistent lack of breeding dating from 1970. Freshwater wetland losses at the site have been extensive. Seasonally flooded wetlands east of the site have been drained for housing and rice production, and the Caroni River has been channelized and diked to reduce rainy-season overflow. A four-lane, interstate-grade highway acts as a dam to freshwater surface flow into the swamp. As a result, most of the freshwater wetlands within the site are now brackish, and formerly freshwater herbaceous portions of the swamp are now dominated by mangrove forest (Bildstein 1990).

Studies of the breeding ecology of the closely related White Ibis in coastal North America suggest a link between saltwater intrusion and the cessation of Scarlet Ibis breeding activity in the Caroni Swamp. During the breeding season, parental White Ibises switch from feeding in coastal marshes on brackish-water prey to feeding almost exclusively on freshwater prey, even when this involves traveling great distances inland to do so (Bildstein et al. 1990). Experiments with hand-reared nestlings demonstrate that the dietary shift results from a physiological bottleneck in nestlings that precludes their normal growth and development on high-salt diets (Johnston and Bildstein 1990). Historical observations in Trinidad of Scarlet Ibises shifting to feed on freshwater prey during the breeding season (ffrench and Haverschmidt 1970) support the link between saltwater intrusion and a lack of breeding activity in the Caroni Swamp.

Many conservationists have called for the protection or sustainable development of mangrove swamps in coastal Central and South America. Mangrove swamps, however, are open systems and, as the above example of saltwater intrusion suggests, their protection alone will not ensure the ecological integrity of such sites. Therefore, we suggest that agencies involved in coastal-zone management consider not only coastal mangrove swamps, but also adjacent freshwater wetlands in their attempts to maintain such resources for sustainable use.

Mexico's Usumacinta-Grijalva delta.—This nearly pristine 10 million-ha wetland in Mexico's Gulf Coast states of Tabasco and Campeche, has been likened to the Mississippi River delta prior to its human modification. The delta, which is the site of the country's largest mangrove forest (currently estimated at approximately 110,000 ha), supports Mexico's highest populations of breeding colonial waterbirds, including the largest Wood Stork colony in North America. The Usumacinta-Grijalva is also the last stronghold for Mexico's dwindling population of Jabiru Storks (*Jabiru mycteria*). The Mexican government is currently considering establishing a 290,000-ha Biosphere Reserve in the Tabasco portion of the wetland. Unfortunately, PEMEX, Mexico's national petroleum company, has recently discovered high-grade crude oil at the site, threatening the site with development for its energy resources. In addition, portions of the Usumacinta-Grijalva wetland are being modified for both rice and cattle production. This, together with recent road construction and the erection of several dams on the Usumacinta River have substantially altered the hydrology of the wetland. Indigenous inhabitants appear to be using the wetland in a sustainable fashion (e.g., the country's largest shrimp fishery is found at the site). Whether the site will be maintained intact as a functioning unit will, to a great extent, depend upon the resolve of the Mexican Government to carry through on its promised designation of the site as a UNESCO Biosphere Reserve (Rude 1989).

Coastal-zone planning in Brazil.—During the 1980s, national concern for Brazil's coastal ecosystems has grown almost as rapidly as has international concern for the Amazon. Stretching some 7500 km, the Brazilian coast contains numerous estuaries and lagoons that for centuries have played a critical role in the economy of the country. Today, however, the population of three major Brazilian cities alone (Sao Paulo, Rio de Janeiro, and Belo Horizonte) totals 30 million people. Growing population pressure in the coastal zone, coupled with a rising demand for economic growth, has resulted in the severe degradation of many coastal ecosystems. Populations of fishes, shrimps, oysters, and crabs are dangerously contaminated with mercury and other heavy metals, while demand for agricultural land is leading to reclamation of coastal land and diversion of freshwater from many estuarine systems, thus reducing their productivity (cf. Neves 1989).

In response to development pressure, there is now increasing awareness of the importance of coastal wetlands and the need for urgent action to ensure that these systems will continue to yield a diversity of benefits. In 1988 the Brazilian government enacted a National Coastal Zone Management Plan (PNGC), and a number of governmental and nongovernmental projects are now underway along the coast, including the "macrozoning" of the region based on information organized in 30′ by 30′ geographical sections (Frischeisen et al. 1989). Twelve classes of coastal types have been established, including Ecological Conservation Areas, Scientific Research Areas, Ports and Terminals, Urban Expansion, Farming Activities, Aquaculture Activities, etc. Ecological Conservation Areas, for example, include portions of the Mata Atlantica, a coastal-zone tropical rain forest, which would be preserved in an attempt to maintain the natural hydrological cycle of the region, as well as the deltas of most major rivers, and mangroves (Azevedo et al. 1989).

To be successful, conservation efforts need to go beyond management of individual estuaries and address broader issues related to the distribution, form, and intensity of all economic activities in the coastal zone. This will require extensive consultation at local, state, and federal levels, a task that has been greatly facilitated by the establishment of the International Commission for Marine Resources, which has provided leadership and guidance to work undertaken by individual states.

An example of the type of initiative supported by the Commission is a conservation program for the Iguape-Cananeia-Paragua estuary system in Sao Paulo and Parena states. A coastal-zone management plan that identifies the most promising management options and economic investment has been developed for the estuaries and surrounding basins. In preparing the plan, conflicting issues were resolved by a coastal committee of representatives of government institutions, fishermen and peasant associations, entrepreneurs, and environmental groups.

Along with the management plan, the program has taken steps to improve the living conditions of the people and to encourage their cooperation with conservation actions. Improvements include support to oyster farming, subsidizing transport of farm products and fish and oysters, and helping to establish a facility for fish-smoking. Because smoked fish can be transported more easily than fresh fish, and therefore are more valuable, the program increases local income without increasing demand on the resource.

Conclusions.—The message from these Caribbean and Latin American examples is clear. The conservation of coastal wetlands is a complex process, which today reaches far beyond the traditional, wildlife-oriented approach of simple wetland preservation. Only by considering the full range of issues, including the biological importance of the resources, the uses made of these resources by local inhabitants and their importance to the local economy, external threats from pollution and water diversion, and the administrative structures at the local and national level that will oversee and implement management, can longterm success be achieved.

INTERNATIONAL PROGRAMS

Here we provide information on two international programs, the Western Hemisphere Shorebird Reserve Network (WHSRN) and the North American Waterfowl Management Plan (NAWMP), both of which are involved in coastal wetland conservation in the Western Hemisphere. Although not described herein, several other international groups, including the International Waterfowl and Wetlands Research Bureau (IWRB; Slimbridge, England) and the International Union for the Conservation of Nature and Natural Resources (IUCN; Gland, Switzerland), are also actively engaged in the conservation of coastal wetlands in the New World. IWRB, for example, has just published the results of a symposium on Scarlet Ibis conservation (Frederick et al. 1990), and is currently cooperating with WHSRN in a joint census of Neotropical shorebirds and waterfowl. IUCN, on the other hand, is currently preparing a document that will focus on the sustainable development and wise use of the world's wetland resources.

The Western Hemisphere Shorebird Reserve Network.—WHSRN was launched in 1985 in response to declining shorebird populations and disappearing wetlands. Initial collaborating groups included the International Association of Fish and Wildlife Agencies, the World Wildlife Fund, and the Academy of Natural Sciences of Philadelphia, the Canadian Wildlife Service, National Audubon Society, and Manomet Bird Observatory (Myers et al. 1987). The network brings together wildlife agencies, land owners, private conservation groups, and others to solve conservation challenges faced by migrating shorebirds and the wetlands they use. Membership and participation in WHSRN is voluntary; management authority and priorities remain the prerogative of the land administrator. The Network's success ultimately depends upon the involvement of enthusiastic people in wildlife agencies, park systems, governments, and private groups that own and manage wetlands.

WHSRN is compatible with and encourages participation in other national or international conservation programs, and supports a variety of conservation approaches, including sustainable development and critical management. Several WHSRN sites are wetlands protected under the Ramsar Convention. The U.S. Fish and Wildlife Service has nominated a number of National Wildlife Refuges for inclusion in the system, as has the Suriname Forest Service.

To be included in the network, a site must meet certain biological criteria. Hemispheric Reserves are used by at least 500,000 shorebirds annually or 30% of a flyway population. International Reserves host at least 100,000 shorebirds annually or 15% of the flyway population. Regional Reserves host 20,000 shorebirds annually or 5% of the flyway population. Endangered Species Reserves are of critical importance to the survival of an endangered shorebird species; no minimum number of birds is required. Pairing or "twinning" of sites that share high numbers of the same species at different points in the hemisphere reinforces cooperation on a hemisphere level and facilitates exchange of scientific data. As of the spring of 1991, 11 Hemispheric and three International reserves have been included in the Network, with many others waiting in the wings. Reserves include Delaware Bay, USA; Bay of Fundy, Canada; Wia-Wia, Coppename, and Bigi Pan, Suriname; Stillwater NWR, USA; San Francisco Bay, USA; Cheyenne Bottoms, USA; Laguna Mar Chiquita, Argentina; Copper River Delta, USA; Maryland-Virginia Barrier Islands; Lagoa do Peixe, Brazil; and Mono Lake, USA. Sites in Canada's Bay of Fundy and coastal Suriname have been "twinned." The establishment of the Stillwater site has led Congress and the Federal government to take the precedent-setting step of buying water rights for wildlife refuges.

WHSRN works cooperatively on many levels to increase research and management efforts to benefit shorebirds and wetlands. In the neotropics WHSRN co-sponsors workshops for biologists and policy makers. Field workshops offer participants the opportunity to develop biological skills necessary for gathering data on wetlands and shorebirds. Policy-management workshops offer management information and discussions of current and proposed management plans. As of spring 1991, workshops have occurred in Argentina, Chile, Brazil, Ecuador, Mexico, Peru, and Venezuela. In North America WHSRN works with multiagency efforts such as the North American Waterfowl Management Plan to increase management possibilities for shorebirds and other nogame wetland species at some joint ventures.

The Network operates through a representative council and staff. The former establishes policy, offers guidance, and stimulates development of the Network. The latter works to bring new sites into the Network, provide management guidelines, research information, and educational materials to existing sites, coordinate neotropical workshops, manage data bases, and inform the public. The Network's philosophy is to build on existing resources and to unify local and regional groups, rather than to import expertise. Additional information about the program is available from WHSRN, Manomet Bird Observatory, Manomet, Massachusetts 02345, USA.

The North American Waterfowl Management Plan.—Recognizing the need to reverse precipitous declines in North American waterfowl populations and the continent-wide destruction of wetland habitats, in 1986, representatives of the United States and Canada co-signed an historic document called the North American Waterfowl Management Plan (NAWMP). NAWMP is an international strategy that provides a cooperative framework for waterfowl conservation and management efforts between the two countries through the year 2000. The program is designed to promote the longterm perpetuation of North American waterfowl populations through the protection, restoration, and management of an appropriate distribution and diversity of high quality waterfowl habitat across North America (Fig. 5).

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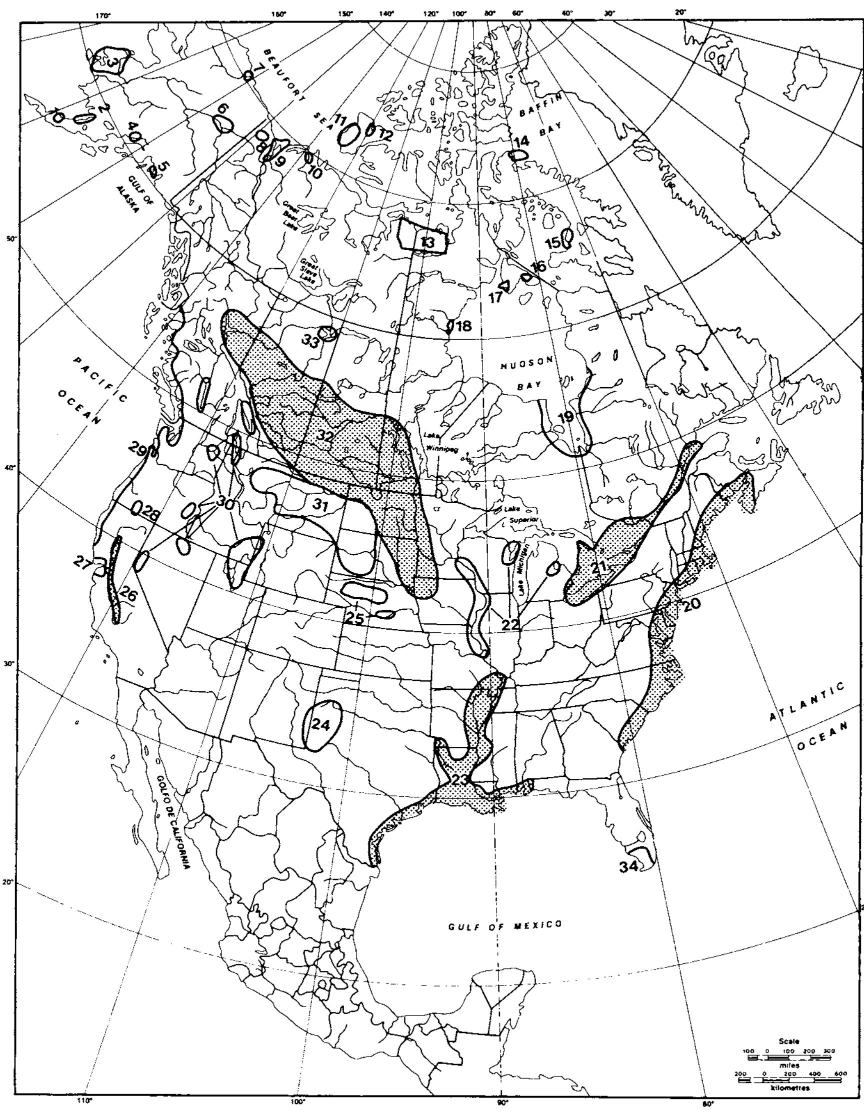
FIG. 5. Waterfowl habitat areas of major concern in the United States and Canada (1, Izembek Lagoon; 2, Upper Alaska Peninsula; 3, Yukon-Kuskokwim Delta; 4, Upper Cook Inlet; 5, Copper River Delta; 6, Yukon Flats; 7, Teshepuk Flats; 8, Old Crow Flats; 9, Mackenzie River Delta; 10, Anderson River Delta; 11 and 12 Banks Island, 13, Queen



Maud Gulf; 14, Bylot Island; 15, Dewey Soper; 16, East Bay; 17, Harry Gibbons; 18, McConnell River; 19, James Bay Lowlands; 20, Middle-Upper Atlantic Coast; 21, Lower Great lakes-St. Lawrence Basin; 22, Upper Mississippi River and Northern Lakes; 23, Lower Mississippi River Delta and Gulf Coast; 24, Playa Lakes; 25, Sandhills and Rainwater Basin; 26, Central Valley; 27, San Francisco Bay; 28, Klamath Basin; 29, Middle-Upper Pacific Coast; 30, Intermountain West; 31, Northern Great Plains; 32, Prairie Potholes and Parklands; 33, Peace-Athabasca Delta; 34, Southern Florida). (A similar map appears in publications of the North American Waterfowl Management Plan.)

NAWMP has set population goals for 32 species of ducks, geese, and swans; has identified habitat conservation needs and goals (in excess of 2,400,000 ha) for specific regions of the continent and provided an international plan of action to achieve these goals. Because the loss and degradation of habitat is perceived as the major problem facing waterfowl management in North America, NAWMP emphasizes that the continued maintenance and restoration of wetlands is necessary to provide suitable habitat for waterfowl and many other wetland-dependent species.

The Plan's ambitious goals, large geographic scope, and projected costs in excess of $1.5 billion mean that its successful implementation will occur only with the participation and close cooperation of both public and private organizations in the U.S. and Canada. This has been accomplished through the membership of the Plan's three standing governing bodies. The 12 member North American Waterfowl Management Plan Committee includes representatives of the U.S. Fish and Wildlife Service, the four flyway councils, the Canadian Wildlife Service, and the Canadian provinces and territories. NAWMP Implementation Boards for the U.S. and Canada, operating under this committee, include representatives from Ducks Unlimited, Inc., Ducks Unlimited Canada, the National Fish and Wildlife Foundation, The Nature Conservancy, the National Audubon Society, Wildlife Habitat Canada, the American Farmland Trust, WHSRN, and the American Forest Foundation, among others. Together, these three groups oversee the development, coordination, funding, and review of NAWMP activities.

In addition to the above continental committees, regional Joint Ventures that are coalitions of state and federal agencies, conservation groups, and individuals have been established for key habitat priority areas. The six Joint Ventures in the United States are the Atlantic Coast, Lower Great Lakes-St. Lawrence Basin, Lower Mississippi Valley, Prairie Pothole Region, Gulf Coast, and Central Valley of California. Detailed Joint Venture Plans identify regional goals and objectives for restoring waterfowl populations and wetland habitats. Partners in each Joint Venture combine their collective resources and cooperate in planning, funding, and implementing projects.

Funding for NAWMP comes from many sources. Initially, money was generated through an innovative challenge-grant program in which $1,000,000 contributed by 12 state fish and wildlife agencies was matched by Ducks Unlimited. This amount was matched again by the National Fish and Wildlife Foundation and Canadian government, resulting in an $8,000,000 program, which has been spent primarily on the Prairie Habitat Joint Venture in Canada. As NAWMP has become a reality and garnered additional support, substantial funds are being directed to NAWMP Joint Venture activities by participating government agencies, conservation groups, and private individuals. The North American Wetlands Conservation Act (see below) will provide a significant source of federal funds for NAWMP wetland conservation projects.

Many creative strategies are being used to meet the goals and objectives of NAWMP Joint Ventures, including fee-title land acquisitions; restrictive conservation easements; cooperative agreements among corporations, public agencies, and private landowners; leases; financial incentives; technical assistance; and information and education programs, all of which are being successfully used to protect and enhance key wetland and associated upland habitats. Efforts are also underway through NAWMP to improve government regulatory and assistance programs that impact wetlands acquisition, restoration, management, and enhancement activities, and to improve existing federal agency land acquisition and management programs.

NAWMP will play an important role in the conservation of coastal wetland ecosystems important to waterfowl and other wetland-dependent species. Both the Atlantic Coast and Gulf Coast Joint Ventures focus on major coastal wetland regions of the United States. Projects in both joint ventures are already underway to protect key wetlands from further loss and degradation due to impacts from residential and commercial development, industry, navigation, agriculture, and intensifying recreational use. Many of these projects have been designed to encompass large-scale coastal upland-wetland complexes with the intent of protecting and enhancing functional wetland ecosystems that benefit the most species. The ACE Basin Project in South Carolina, the Cape May Project in New Jersey, and the Milford Neck Project in Delaware are good examples of this aspect of NAWMP.

The 140,000-ha Ashepoo, Combahee, and Edisto (ACE) Rivers Basin is one of the largest remaining undeveloped coastal wetland ecosystems along the U.S. Atlantic Coast. The basin encompasses several undeveloped barrier islands; approximately 37,000 ha of tidal marsh, including 26,000 acres of salt marsh, 5500 ha of brackish marshes, and 4900 ha of freshwater marshes; and over 22,000 ha of forested wetlands. Approximately 10,500 ha of managed wetland impoundments are interspersed within the three tidal zones. This diverse complex of wetland communities and associated uplands performs many important functions and has great value as a natural resource.

The ACE Basin has been identified as a unique coastal wetland ecosystem of national and regional significance through the criteria of the National Wetlands Priority Conservation Plan (Emergency Wetlands Resources Act of 1986) and has been listed as a target for preservation in the Draft Southeast Regional Wetlands Concept Plan. The basin's value to wildlife and the overall ecological significance of the area as a largely intact coastal wetland system have spawned a major initiative to preserve the area in perpetuity.

Identified as a flagship project of the NAWMP Atlantic Coast Joint Venture, the ACE Basin Project exemplifies NAWMP efforts to protect entire coastal wetland systems. The project is comprehensive in scope, with the overall objective being to protect, enhance, restore, and manage an appropriate distribution and diversity of wetlands and associated uplands for migratory birds and other wildlife. Consideration is given to threatened and endangered species (e.g., Bald Eagle [*Haliaeetus leucocephalus*], Wood Stork), estuarine fisheries, and unique and valuable plant communities.

Planning and implementation of the ACE Basin Project is being coordinated through the cooperative efforts of Ducks Unlimited, Inc., the South Carolina Wildlife and Marine Resources Department, the U.S. Fish and Wildlife Service, The Nature Conservancy, the National Fish and Wildlife Foundation, and many private landowners. Together, these partners have developed an innovative strategy to preserve the ACE Basin using voluntary conservation easements by private landowners and public and private land acquisitions. Presently, over 4800 ha of brackish and freshwater wetlands are protected within a state wildlife management area. The U.S. Fish and Wildlife Service is proceeding with the establishment of a 7300-ha National Wildlife Refuge, and another 6500 ha will be protected within a National Estuarine Research Reserve (see below). The Nature Conservancy is working with private landowners to protect additional wetlands and adjacent uplands through conservation easements. Ducks Unlimited is coordinating protection strategies involving easements and fee acquisitions for other parcels of property key to maintaining the ecological integrity of the basin's wetland ecosystem. All aforementioned cooperators have provided funds to support Project activities, and additional funding from the North American Wetlands Conservation Act is anticipated.

UNITED STATES GOVERNMENT PROGRAMS

Many segments of the U.S. government are involved in wetland conservation. Here, we describe recent actions of the Executive and Legislative branches, together with those of a number of key agencies, including the U.S. Fish and Wildlife Service (FWS), the National Park Service (NPS), the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Army Corps of Engineers (COE).

The Executive Branch.—President Bush has taken an active posture in declaring that there will be "no net loss" of wetlands in the U.S. This declaration was a response to the recommendations of the National Wetlands Policy Forum report (The Conservation Foundation 1988), which can be summarized as follows.

First, an emphasis is placed on protecting wetlands by reducing losses and increasing restoration efforts. Second, efforts are to be aimed at improving protection and management processes through regulatory programs and education. Third, implementation of the Forum's recommended program requires that Congress enact legislation that will establish wetland protection goals as national policy, that qualified states be granted stronger wetlands regulatory responsibilities, that incentives such as Wetland Preservation Trusts and an Agricultural Wetlands Reserve Program be established, and that the President be required to report to Congress every five years on progress on national wetlands goals.

Parts of the Forum report have been controversial (Wood 1990). There is some debate over the relative roles of states and the Federal government in wetland permit administration and protection. Major differences exist in the level of state protection of wetlands across the U.S.

President Bush appointed a Domestic Policy Council to develop an interagency document to guide future Federal actions. This council has to deal with competing interests of conservation, land development, and oil and gas leases. Progress has proved to be slow because of conflicts over energy development and transportation in Alaska and preoccupation with the Clean Air Act.

U.S. Fish and Wildlife Service.—The FWS has planned or recently initiated a number of important ventures that bear directly on wetland conservation. The North American Waterfowl Management Plan (described above) has received a major boost with the passage of the North American Wetlands Conservation Act.

In response to the President's call for "no net loss" of wetlands, the FWS has developed a step-down plan for a wetlands initiative, "Wetlands: Meeting the President's Challenge." This document (still under review in the Department of the Interior) takes a three-prong approach to "no net loss." First, it focuses on reducing and trying to eliminate the rate of loss, using the regulatory process, easement or lease programs, review of Federal projects, and cooperative efforts with other agencies and with public and private organizations. Second, wetland restoration, enhancement, and management will be emphasized. Greater effort will be expended, both on National Wildlife Refuges and other public and private lands, to benefit waterfowl and other wildlife, including endangered species. Wetlands creation, because of the many technical problems, remains a tool with limited application at present. Third, a stronger thrust will be directed at wetlands research, information transfer, and education. Research will be directed at wetland functioning at the community and ecosystems levels. Education and research will be expanded in the hemisphere under the Ramsar Convention.

Under the umbrella of the Wetlands Initiative, the FWS has formed a Coastal-Estuary Working Group. The draft report of that group recommends that the Director improve coordination with other agencies, especially EPA, NOAA, and COE. It reiterates many of the same research, management, and education goals of the Initiative, but calls for a stronger research thrust into wetlands functioning. It also recommends the removal of economic subsidies for coastal development, such as was done through passage of the Coastal Barrier Resources Act in 1982 (see below). It suggests that a FWS national coastal and estuary program be established. There already exists a Chesapeake Bay Estuary Program, as well as new programs began in 1989 in Delaware Bay, in southern New England, and on Long Island Sound. Plans are being made to expand to Galveston Bay and, later Puget Sound.

The FWS National Wetland Inventory has produced detailed 1:24,000-scale wetland maps for the entire coastal zone of the conterminous United States, Hawaii, and the Great Lakes. Maps are available by calling 1-800-USA-Maps (in Virginia, [703] 648-6045).

National Park Service.—The NPS has been embroiled in recent controversy over its policies on National Seashores concerning offroad vehicle permits on beaches, dunes, and associated wetlands. Legal decisions on Cape Cod National Seashore have supported the agency's ability to uphold restrictions for the protection of the endangered Piping Plover and other beach-dependent species. However, recreational versus conservation conflicts remain at Fire Island, Cape Hatteras, Assateague, and other National Seashores. Although beaches, arguably, may not be considered wetlands, disturbances from vehicular traffic on outer beaches and dunes certainly have indirect effects that extend to adjacent wetland use by birds.

At Fire Island National Seashore on Long Island, New York, the NPS has also initiated wetland restoration projects in salt marshes that have been altered for mosquito control. These projects should enhance the value of these wetlands to waterbirds and shorebirds. At the NPS Jamaica Bay Refuge, also on Long Island, park personnel have been managing water levels at two impoundments for shorebirds (P. Buckley, pers. comm.).

As indicated above, the passage of the recent Everglades National Park expansion has been a major conservation victory for wetlands and wildlife. Another major confrontation has occurred with regard to water rights in the Park. Legal action is pending between the South Florida Management District and the Department of Justice concerning agricultural water uses and runoff into the Everglades. There is major concern within the conservation community that both water quantity and quality must be enhanced if there is to be any success in restoring wildlife and fish to the region.

National Oceanic & Atmospheric Administration (Department of Commerce).—NOAA has several programs that are relevant to wetland conservation, including:

(a) The National Estuary Inventory Program.—The intent of the program is to assimilate biological, chemical, and physical data on estuaries into a system compatible with desk-top computers. This system is intended to be used to identify water-quality problems, map important resource areas, and identify trends of resource changes over time and space. Nationwide, NOAA's program supports an inventory of 120 estuaries. Program goals show some overlap with the FWS Coastal-Estuary Program and EPA-sponsored projects in many estuaries.

(b) The National Estuarine Research Reserve Network.—This program matches Federal with state funds on a 50:50 basis to support research on 18 reserves, ranging from one to 196,000 ha. These reserves are under state protection. Twelve of the current reserves are on the Atlantic Coast, one is on the Great Lakes, one in Hawaii, and four on the West Coast. Four of the five currently under consideration are on the East Coast. The network protects important wetland habitats for birds, augmenting the lands within the National Wildlife Refuge system, National Seashores, and other public and private wildlife sanctuaries.

(c) The Coastal Ocean Program.—This new program has a large research component. It focuses on energy flows and modeling and includes ocean systems, ocean-coastal interactions, and upland-estuary coupling.

U.S. Army Corps of Engineers.—In a number of districts, the COE has become much more responsive in recent years to concerns for wetland quality, as well as quantity. With respect to bird conservation issues, there are a number of examples where dredge operators have worked cooperatively with biologists in adding fresh-dredged material to currently existing islands in attempts to enhance the habitat for nesting colonial waterbirds. A recent emphasis has been closer cooperation among regulatory personnel in COE, EPA, and FWS.

The momentum of the "no net loss" initiative was slowed by negotiations over details of a memorandum of agreement between COE and EPA. Sensitive issues had to do with the concept of "sequencing," whereby wetland loss is, first, to be avoided, second, to be minimized, and third, to be mitigated by creation or restoration. Points of contention dealt mainly with dredging operations under Section 404 guidelines of the Clean Water Act. Now that the agreement has recently been signed, progress on "no net loss" should continue through 1990.

The Environmental Protection Agency.—As indicated above, a recent hurdle has been overcome with respect to how dredge and fill operations proceed and how final authority for permit issues is resolved. There is broad recognition at all levels of government that there is too much "red tape" involved in regulatory matters and that there is often no clear lead agency on a number of wetland issues. The EPA appears to have broadened its mission in recent years, going beyond traditional water-quality concerns in wetlands.

The EPA has launched a new initiative called the Environmental Monitoring and Assessment Program (EMAP). The initiative has implications for wetland quality and conservation because of its intent to monitor physical, chemical, and biological resource data on a national scale, using 12,500-grid sampling points. Waterbird abundance is one of seven wetland "condition" parameters being proposed for monitoring. The program, which carries a price tag of well over $100 million, is intended to integrate monitoring over all Federal resource agencies.

Legislative Branch.—Several acts have been signed into law recently that have a direct bearing on waterbird conservation in the U.S.:

(a) The Everglades National Park Protection and Expansion Act, signed in late 1989, authorizes, pending the necessary appropriations, expansion of the park by 44,350 ha on the northeastern boundary. It also bans most uses of airboats in the park.

(b) The North American Wetlands Conservation Act, also signed in late 1989, emphasizes wetlands protection for migratory birds in the U.S., Canada, and Mexico. The law highlights endangered species and migratory nongame birds as well as waterfowl. A funding base is established that taps three sources of funding: interest on investments from Pittman-Robertson funds, additional funding (up to $15 million) from Department of Interior appropriated funds, and a smaller amount from fines, penalties, and forfeitures from Migratory Bird Treaty Act violations. Matching (non-Federal) funds are to be used for all projects; proposals submitted are reviewed by a new council that makes recommendations to the Migratory Bird Commission for funding. From 50-70% of the anticipated $50 million per year is to be used for projects in Canada and Mexico.

Two other major bills are pending that also have major implications for bird conservation in wetlands:

(a) The Louisiana Coastal Wetlands Conservation and Restoration Act would develop a plan to slow the loss of state wetlands, design a permit program for development activities in wetlands with provisions for no net loss of area, and set up a fund to finance coastal restoration projects. The major sticking point so far has been the financial provision. One suggestion has been that 5% of the oil and gas lease revenues from the outer continental shelf be set aside as a trust. Work on the bill continues.

(b) The Coastal Barriers Resources Act (COBRA), pending in the House, would add 320,000 ha of Atlantic and Gulf Coast land and 23,000 ha of coastal habitat in the Great Lakes to the existing Coastal Barrier Resources System and would map the Pacific Coast for area designations. The most current version of the bill deals only with private lands, omitting military and NPS lands under COBRA. The original legislation, which was signed in 1982, withdrew Federal subsidies for development of what were then undeveloped barrier islands on the Atlantic Coast.

As this summary indicates, many aspects of wetland conservation, management, and research are on the forefront of Federal actions, in large part as a consequence of the current pledge of "no net loss." If the recommendations of the National Wetlands Policy Forum are implemented, a great amount of Federal and state resources will need to be marshalled to ensure that wetland losses and alterations are reduced, that the regulatory process is improved, and that economic and other incentive programs are put in place to augment current Federal, state, and private wetland holdings.

SUMMARY AND RECOMMENDATIONS

Although coastal wetlands comprise less than 3% of the land surface of the Western Hemisphere, these areas include some of the most productive and ecologically valuable of all natural habitats. Approximately half of the hemisphere's human population lives near and depends on coastal wetlands which are open ecological systems that can be used by human populations in a sustainable manner. Unfortunately, many coastal wetlands continue to be altered detrimentally, both directly and indirectly, at an alarming rate by the actions of human populations throughout the hemisphere.

The committee recommends (1) that appropriate local, state, and natural governmental and nongovernmental organizations in the Western Hemisphere enhance and ensure the protection of these important ecological resources by supporting essential research, by the passage of new protective and regulatory legislation as warranted, and by the enforcement of existing laws concerning wetland use; (2) that nations that have not already done so, become contracting parties to the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the so-called RAMSAR Convention), that all nations adhere to both the spirit and letter of this international treaty, and that they actively promote the wise and sustainable use of coastal wetlands within and beyond their jurisdictions, (3) that nations create strong local and national conservation programs, and that they become involved with the Western Hemisphere Shorebird Reserve Network, the North American Waterfowl Management Plan, and other international programs fostering similar goals, (4) that nations with useful technical information provide such information to other nations so that the latter may make informed decisions concerning the management of their coastal resources, and (5) that educational campaigns be initiated throughout the hemisphere to heighten public awareness of the plight of coastal wetlands, thereby increasing the likelihood that these valuable resources will be used wisely.

ACKNOWLEDGMENTS

Numerous individuals have contributed information to the authors of this report. We especially thank those cited herein for their personal communications. M. Howe, R. Jachowski, W. Wilen, and two anonymous referees made useful comments on parts of earlier drafts of the report. C. Hagen assisted in typing. The Wilson Ornithological Society facilitated the distribution of this report to numerous governmental and nongovernmental agencies throughout the Western Hemisphere. KLB's efforts have been supported, in part, by NSF-LTER funds granted to the Belle W. Baruch Institute of Marine Biology and Coastal Research. His portions of the report constitute contribution number 853 of the Institute.

LITERATURE CITED

ABRAHAMSON, D. E. 1989. The challenge of global warming. Island Press, Washington, D.C.

ALEXANDER, C. E. AND M. A. BROUTMAN. 1986. An inventory of Coastal Wetlands of the U.S.A. N.O.A.A., Washington, D.C.

ARTHINGTON, A. H. AND E. J. HEGERL. 1988. The distribution, conservation status and management problems of Queensland's athalassic and tidal wetlands. Pp. 59–101 *in* The conservation of Australian wetlands (A. J. McComb and P. S. Lake, eds.). Surrey Beatty & Sons, New South Wales, Australia.

ATWOOD, J. L. AND B. W. MASSEY. 1988. Site fidelity of Least Terns in California. Condor 90:389–394.

AZEVEDO, L. H. A., D. M. W. ZEE, AND D. R. TENENBAUM. 1989. Coastal zone planning. Pp. 70–83 *in* Coastlines of Brazil (C. Neves, ed.). Am. Soc. Civil Engineers, New York, New York.

BANCROFT, G. T. 1989. Status and conservation of wading birds in the Everglades. Am. Birds 43:1258–1265.

———, A. M. STRONG, R. J. SAWICKI, W. HOFFMAN, AND S. D. JEWELL. Foraging distribution of wading birds relative to breeding within the Everglades system *in* Proceedings of the Everglades symposium. In press.

BERGSTROM, P. W. 1988. Breeding biology of Wilson's Plovers. Wilson Bull. 100:25–35.

BILDSTEIN, K. L. 1990. Status, conservation and management of the Scarlet Ibis *Eudocimus ruber* in the Caroni Swamp, Trinidad, West Indies. Biol. Conserv. 54:61–78.

———, R. CHRISTY, AND P. DECOURSEY. 1982. Size and structure of a South Carolina salt marsh avian community. Wetlands 2:118–137.

———, W. POST, P. FREDERICK, AND J. JOHNSTON. 1990. Freshwater wetlands, rainfall, and the breeding ecology of White Ibises in coastal South Carolina. Wilson Bull. 102: 84–98.

BURGER, J. 1982. The role of reproductive success in colony-site selection and abandonment in Black Skimmers (*Rynchops niger*). Auk 99:109–115.

———. 1984. Colony stability in Least Terns. Condor 86:61–67.

———. 1985. Habitat selection in temperate marsh-nesting birds. Pp. 253–281 *in* Habitat selection in birds (M. L. Cody, ed.). Academic Press, New York, New York.

———. 1987. Physical and social determinants of nest-site selection in Piping Plover in New Jersey. Condor 89:811–818.

——— AND J. SHISLER. 1980. Colony and nesting site selection in Laughing Gulls in response to tidal flooding. Condor 82:251–258.

CHERFAS, J. 1990. The fringe of the ocean—under siege from land. Science 248:163–165.

CONNORS, P. G., J. P. MYERS, AND F. A. PITELKA. 1979. Seasonal use by arctic Alaskan shorebirds. Stud. Avian Biol. 2:101–111.

THE CONSERVATION FOUNDATION. 1988. Protecting America's wetlands: an action agenda. (The final report of the National Wetlands Policy Forum.) The Conservation Foundation, Washington, D.C.

DAVIS, S. M. 1989. Sawgrass and cattail production in relation to nutrient supply in the Everglades. Pp. 325–341 *in* Freshwater wetlands and wildlife (R. R. Sharitz and J. W. Gibons, eds.). Office of Scientific and Technical Information, U.S.D.E., Oak Ridge, Tennessee.

DAY, J. W. JR., C. A. S. HALL, W. M. KEMP, AND A. YANEZ-ARANCIBIA. 1989. Estuarine ecology. Wiley, New York, New York.

DERKSEN, D. V., T. C. ROTHE, AND W. D. ELDRIDGE. 1981. Use of wetland habitats by birds in the National Petroleum Reserve—Alaska. U.S.F.W.S. Resour. Publ. 141, Washington, D.C.

EMANUEL, K. 1987. The dependence of hurricane intensity on climate. Nature 326:483–485.

ERWIN, R. M., J. GALLI, AND J. BURGER. 1981. Colony site dynamics and habitat use in Atlantic coast seabirds. Auk 98:550–561.

FEIERABEND, J. S. AND J. M. ZELAZNY. 1987. Status report on our nation's wetlands. Natl. Wildl. Fed., Washington, D.C.

FFRENCH, R. 1978. Birds of the Caroni Swamp and marshes. Living World (J. Field Nat. Cl. Trinidad & Tobago) 1977:42–44.

———. 1980. A guide to the birds of Trinidad and Tobago. Harrowood Books, Newton Square, Pennsylvania.

——— AND F. HAVERSCHMIDT. 1970. The Scarlet Ibis in Surinam and Trinidad. Living Bird 9:147–165.

FRAYER, W. E., T. J. MONAHAN, D. C. BOWDEN, AND F. A. GRAYBILL. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950s to 1970s. Department of Forest and Wood Sciences, Colorado State University, Ft. Collins, Colorado.

FREDERICK, P. 1987. Chronic tidally-induced nest failure in a colony of White Ibises. Condor 89:413–419.

FREDERICK, P. C. AND M. W. COLLOPY. 1989. Nesting success of five Ciconiiform species in relation to water conditions in the Florida Everglades. Auk 106:625–634.

———, L. G. MORALES, A. L. SPAANS, AND C. S. LUTHIN, eds. 1990. The Scarlet Ibis (*Eudocimus ruber*): status, conservation and recent research. I.W.R.B. Spec. Publ. No. 11, Slimbridge, England.

FRISCHEISEN, E. R., M. S. F. ARGENTO, R. HERZ, AND R. P. CARNEIRO. 1989. The coastal management program in Brazil. Pp. 1–9 *in* Coastlines of Brazil (C. Neves, ed.). Am. Soc. Civil Engineers, New York, New York.

GAGLIANO, S. M., K. J. MEYER-ARENDT, AND K. M. WICKER. 1981. Land loss in the Mississippi River deltaic plain. Trans. Gulf Coast Assoc. Geol. Soc. 31:295–299.

GARNER, G. W. AND P. E. REYNOLDS, eds. 1986. Arctic National Wildlife Refuge Coastal Plain resource assessment. Final report, baseline study of the fish, wildlife, and their habitats. U.S.F.W.S., Anchorage, Alaska.

GOCHFELD, M. 1978. Breeding synchrony in Black Skimmers: colony vs. subcolonies. Proc. Colonial Waterbird Group 2:171–177.

HAIG, S. M. AND L. W. ORING. 1988. Mate, site, and territory fidelity in Piping Plovers. Auk 105:268–277.

HAIR, J. D. 1988. Wanted: a national wetlands policy. Pp. 17–19 *in* Increasing our wetland resources (J. M. Zelazny and J. S. Feierabend, eds.). Natl. Wildl. Fed., Washington, D.C.

HEFNER, J. M. AND J. D. BROWN. 1985. Wetland trends in the southeastern United States. Wetlands 4:1–11.

HELIOTIS, F. D. 1988. An inventory and review of the wetland resources of Greece. Wetlands 8:15–31.

HICKEY, J. J. 1952. Survival studies of banded birds. U.S.F.W.S. Spec. Sci. Rept. Wildl. 15:1–117.

HICKLIN, P. W. 1987. The migration of shorebirds in the Bay of Fundy. Wilson Bull. 99: 540–570.

HOWE, M. A. 1982. Social organization in a nesting population of eastern Willets (*Catoptrophorus semipalmatus*). Auk 99:88–102.

JOHNSTON, J. W. AND K. L. BILDSTEIN. 1990. Dietary salt as a physiological constraint in white ibises breeding in an estuary. Physiol. Zool. 63:190–207.

JONES, P. D. AND T. M. L. WIGLEY. 1990. Greenhouse effect: satellite data under scrutiny. Nature 344:711.

KOTLIAR, N. B., AND J. BURGER. 1986. Colony site selection and abandonment by Least Terns (*Sterna antillarum*) in New Jersey, U.S.A. Biol. Conserv. 37:1–21.

KUO, C., C. LINDBERG, AND D. J. THOMSON. 1990. Coherence established between atmospheric carbon dioxide and global temperature. Nature 343:709–714.

KUSHLAN, J.A. 1976. Wading bird predation in a seasonally fluctuating pond. Auk 93: 464–476.

——— AND P. C. FROHRING. 1986. The history of the southern Florida Wood Stork population. Wilson Bull. 98:368–386.

LAURO, B. AND J. BURGER. 1989. Nest-site selection of American Oystercatchers (*Haematopus palliatus*) in salt marshes. Auk 106:185–192.

LEACH, S. D., H. KLEIN, AND E. R. HAMPTON. 1972. Hydrologic effects of water control and management of southern Florida. Fl. Bur. Geol., Rept. of Invest. 60.

LESTER, R. T. AND J. P. MYERS. 1989. Global warming, climate disruption, and biological diversity. Pp. 177–221 *in* Audubon wildlife report—1989/1990 (W. J. Chandler, ed.). Academic Press, New York, New York.

LIGHT, S. S., J. R. WODRASKA, AND S. SABINA. 1989. The southern Everglades: the evolution of water management. Natl. Forum 69:11–14.

LYSTER, S. 1985. International wildlife law. Grotius, Cambridge, England.

MACVICAR, T. K. 1984. The Rainfall Plan: a new approach to water management for the southern Everglades. South Florida Water Management District, West Palm Beach, Florida.

MALTBY, E. 1988. Wetland resources and future prospects —an international perspective. Pp. 3–14 *in* Increasing our wetland resources (J. Zelazny and J. S. Feierabend, eds.). National Wildlife Federation, Washington, D.C.

MASSEY, B. W. 1974. Breeding biology of the California Least Tern. Proc. Linn. Soc. N. Y. 72:1–124.

MCNICHOLL, M. K. 1975. Larid site tenacity and group adherence in relation to habitat. Auk 92:98–104.

———. 1985. Avian wetland habitat functions affected by water level fluctuations. Pp.87–98 *in* Coastal Wetlands (H. H. Prince and F. M. D'Itri, eds.). Lewis Publ., Chelsea, Michigan.

MEANLEY, B. 1985. The Marsh Hen: a natural history of the Clapper Rail of the Atlantic Coast salt marsh. Tidewater Publ., Centreville, Maryland.

MEIER, M. F. 1990. Reduced rise in sea level. Nature 343:115–116.

MONTEVECCHI, W. A. 1978. Nest site selection and its survival value among Laughing Gulls. Behav. Ecol. Sociobiol. 4:143–161.

MORRISON, R. I. G. AND J. P. MYERS. 1987. Wader migration systems in the New World. Wader Study Group Bull 49(suppl.):57–69.

——— AND R. K. ROSS. 1989. Atlas of Nearctic shorebirds on the coast of South America (2 vols.). Canadian Wildl. Serv., Ottawa, Canada.

MYERS, J. P., R. I. G. MORRISON, P. Z. ANTAS, B. A. HARRINGTON, T. E. LOVEJOY, M. SALLABERRY, S. E. SENNER, AND A. TARAK. 1987. Conservation strategy for migratory species. Am. Sci. 75:18–26.

NEVES, C. 1989. Coastlines of Brazil. Am. Soc. Civil Engineers, New York, New York.

NOL, E. 1985. Sex roles in the American Oystercatcher. Behaviour 95:232–260.

———. 1989. Food supply and reproductive performance of the American Oystercatcher in Virginia. Condor 91:429–435.

——— AND A. LAMBERT. 1984. Comparison of Killdeers, *Charadrius vociferus*, breeding in mainland and peninsular sites in southern Ontario. Can. Field Nat. 98:7–11.

ODUM, E. P. 1978. The value of wetlands: a hierarchical approach. Pp. 16–25 *in* Wetland functions and values: the state of our understanding (P. E. Greeson et al., eds.). Am. Water Resour. Assoc., Minneapolis, Minnesota.

OGDEN, J. C. 1978. Recent population trends of colonial wading birds on the Atlantic and Gulf coastal plains. Pp. 137–153 *in* Wading birds (A. Sprunt, IV, J. C. Ogden, and S. Winckler, eds.). Natl. Audubon Soc. Res. Rept. 7.

———. Comparison of nesting patterns by wading birds in the central and southern Everglades, 1931–1940 versus 1974–1983 *in* Proceedings of the Everglades Symposium. In press.

———, D. A. MCCRIMMON, JR., G. T. BANCROFT, AND B. W. PATTY. 1987. Breeding populations of the Wood Stork *Mycteria americana* in the southeatern United States. Condor 89:752-759.

——— AND S. A. NESBITT. 1979. Recent Wood Stork population trends in the United States. Wilson Bull. 91:512–523.

OSBORN, R. G. AND T. W. CUSTER. 1978. Herons and their allies: atlas of Atlantic Coast colonies, 1975 and 1976. FWS/OBS-77/08, U.S.F.W.S., Washington, D.C.

OVERPECK, J. T., D. RIND, AND R. GOLDBERG. 1990. Climate-induced changes in forest disturbance and vegetation. Nature 343:51–53.

PANNIER, F. AND J. DICKINSON. 1989. Manglares. Fundacion para la Defensa de la Naturaleza (FUNDENA), Caracas, Venezuela.

PARKER, G. G. 1974. Hydrology of the pre-drainage system of the Everglades in southern Florida. Pp. 18–27 *in* Environments of south Florida: present and past (P. J. Gleason, ed.). Miami Geol. Soc. Mem. 2, Miami, Florida.

PIATT, J. F., C. J. LENSINK, W. BUTLER, M. KENDZIOREK, AND D. R. NYSEWANDER. 1990. Immediate impact of the "Exxon Valdez" oil spill on marine birds. Auk 107:387–397.

PORTNOY, J. W. 1977. Nesting colonies of seabirds and wading birds—coastal Louisiana, Mississippi, and Alabama. FWS/OBS-77/07, U.S.F.W.S., Washington, D.C.

POST, R. A. 1990. Effects of petroleum operations in Alaskan wetlands: a critique. Alaska Dept. Fish and Game Tech. Rept. 90-3, Juneau, Alaska.

POST, W. AND S. A. GAUTHREAUX, JR. 1989. Status and distribution of South Carolina birds. Contrib. Charleston Mus. 18:1–83.

ROBERTSON, W. B., JR. AND J. A. KUSHLAN. 1974. The south Florida avifauna. Pp. 414–

452 *in* Environments of south Florida: present and past (P. J. Gleason, ed.). Miami Geol. Soc. Mem. 2, Miami, Florida.

RUDE, K. 1989. In the home of jaguars & jabirus. Ducks Unlimited 53(4):38–43, 66–68.

SARMIENTO, G. 1984. The ecology of Neotropical Savannahs. Harvard Univ. Press, Cambridge, Massachusetts.

SCHLATTER, R. 1989. A message from the Southern American delegate to the standing committee. Ramsar 4:3.

SCHOMER, N. S. AND R. D. DREW. 1982. An ecological characterization of the lower Everglades, Florida Bay and the Florida Keys. FWS/OBS-82/58.1, U.S.F.W.S., Washington, D.C.

SCOTT, D. A. AND M. CARBONELL, compilers. 1986. A directory of Neotropical wetlands. I.U.C.N., Cambridge; and I.W.R.B., Slimbridge, England.

SENNER, R. G. B. 1989. Effects of petroleum operations in Alaskan wetlands. Rept. by Robert Senner and Co. for ARCO Alaska, Inc. and BP Exploration (Alaska) Inc., Anchorage, Alaska.

SEYBERT, A. 1799. Experiments and observations on the atmosphere of marshes. Trans. Am. Phil. Soc. 4:415–428.

SIDLE, J. 1985. Determination of endangered and threatened status for the Piping Plover. Fed. Regis. 50:50720–50734.

SIMON, A. W. 1978. The thin edge: coast and man in crisis. Harper and Row, New York, New York.

SIRY, J. V. 1984. Marshes of the ocean shore. Texas A&M Univ. Press, College Station, Texas.

SMART, M. 1989. The Ramsar Convention in southern America. Ramsar 4:3, 5.

SMITH, R. L. 1990. Ecology and field biology. Fourth Ed. Harper and Row, New York, New York.

SOUTHWORTH, A. D. 1989. Conserving southeastern coastal wetlands. Pp. 223–257 *in* Audubon wildlife report—1989/1990 (W. J. Chandler, ed.). Academic Press, New York, New York.

SPAANS, A. L. AND B. H. J. DE JONG. 1982. Present status of some colonial waterbird species in Suriname, South America. J. Field Ornithol. 53:269–272.

SPETH, J. 1979. Conservation and management of coastal wetlands in California. Stud. Avian Biol. 2:151–155.

TEBEAU, C. W. 1974. South Florida water management. Pp. 362–366 *in* Environments of south Florida: present and past (P. J. Gleason, ed.). Miami Geol. Soc. Mem. 2, Miami, Florida.

TINER, R. W. 1984. Wetlands of the United States: current status and recent trends. U.S.F.W.S., Washington, D.C.

TITUS, J. G., ed. 1988. Greenhouse effect, sea level rise and coastal wetlands. U.S. Environmental Protection Agency, Washington, D.C.

WHITTAKER, R. H. AND G. E. LIKENS, eds. 1971. Primary production of the biosphere. Human Biol. 1:301–369.

WILCOX, L. 1959. A twenty year banding study of the Piping Plover. Auk 76:129–152.

WOOD, L. D. 1990. Section 404 delegaton: a rebuttal to Governor Kean. Natl. Wetlands Newsletter 12:2–3.

ZELAZNY, J. M. AND J. S. FEIERABEND, eds. 1988. Increasing our wetland resources. Natl. Wildl. Fed., Washington, D.C.