The State of Waterbird and Wetland Conservation in the United States: A Review

Prepared by the ACU Wetlands Conservation Sub-Committee

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I. INTRODUCTION

To most conservationists, the words "wetland" and "bird" are inextricably related. Nearly all people that visit wetlands are immediately impressed by the abundance, diversity, and conspicuousness of the bird life present. The functions and values of wetlands, however, go far beyond their intrinsic value as bird habitat. Wetlands provide water purification, flood control, pollution filtration, aquifer recharge, sustenance of fisheries, and nutrient cycling. Wetland loss and degradation not only affect these ecological functions, but also erodes important natural capital upon which sustainable development can proceed.

Notwithstanding their importance, wetlands have been destroyed and degraded for centuries, a trend that continues today. The United States has lost more than 50% of the wetlands present before European colonization (Dahl 1990). Similar trends have been documented throughout the world.

The future of many birds is dependent upon the conservation of wetlands and the end of their rapid destruction. This paper, prepared by the AOU's Wetland Conservation Subcommittee, summarizes basic information on wetland conservation for birds,

and presents practical recommendations for future action. Although this paper is primarily "bird-oriented," it was prepared by a diverse team of national and international experts to place the problem within the broader ecological and political framework where wetland degradation and conservation occurs. It is our hope that this paper will not only serve as a useful summary of the topic, but that it will also stimulate on-the-ground conservation action.

The paper is organized in four main sections. The first describes wetland definitions, types, functions, values, losses, and degradation. The second section reviews the effects of wetland loss and degradation on birds and bird populations. The third section describes and evaluates wetland conservation programs (past and present). The final section provides conclusions and identifies future research and conservation needs.

II. WETLANDS: GENERAL FRAMEWORK

A. WETLAND FUNCTIONS

The functions and values of wetlands span over several geographic scales and hierarchical levels, from population and

local levels to ecosystem and global levels (Odum 1979). At the population, local, and regional scales, wetlands provide valuable breeding, wintering, and migration habitats for a myriad of invertebrates, fishes, amphibians, reptiles, birds and mammals.

At ecosystem, landscape, and global levels, the numerous complex functions of wetlands include hydrology, water quality, productivity, waste assimilation, global cycling and atmospheric stability aspects (Odum 1979). Wetlands function variably as ground water discharge sites and as sites for recharge of underground aquifers, thereby replenishing ground-water supplies (Siegel 1988). Wetlands act in flood control by conveying flood water, or providing flood water storage and dampening the effects of storms by reducing peak flow rates and maintaining flow during dry periods. Wetlands influence surface water retention and soil moisture, reduce bank and soil erosion, and control sediment. Wetlands contribute to improved water quality by removing excess nutrients and chemical contaminants. The exhaustive list of wetland functions and values further includes primary production and decomposition, food chain support, nutrient cycling, and the

provision of harvestable products, including food, fiber, fuel, fish and shellfish, and wildlife (Sather and Smith 1984).

Wetlands are among the most important ecosystems used for recreation, supporting a recreational industry valued at several billion dollars in the U.S. alone. Comprehensive reviews of these and many other values and functions of wetlands can be found in Dugan (1992), Davies and Claridge (1993), and Mitsch and Gosselink (1993).

Wetlands are critical habitats to a very rich bird diversity. The high seasonal and annual productivity of wetlands supports very large numbers of birds (Myers et al. 1987). The unique importance of wetlands for conservation is further illustrated by the extremely high dependence of threatened and endangered species on wetlands. Even though wetlands comprise less than 5% of the total land area of the United States, 70% of federally listed threatened species, and 40% of all federally listed endangered species are wetland dependent (Feierabend 1992). Many of these species are birds.

Geographic variation and dynamics of wetlands result in a dynamic heterogeneous patterns in diversity of resources

available to birds. This has important evolutionary consequences influencing adaptations of birds using wetland resources.

B. WETLAND LOSSES

Despite their crucial ecological importance, wetlands have been destroyed for centuries, a trend that continues today. Originally, the area that now constitutes the 50 United States contained an estimated 392 million acres (159 million ha.) of wetlands: 221 million acres (89 million ha.) in the conterminous United States, 170 million acres (69 million ha) in Alaska, and about 59,000 acres (24,000 ha) in the State of Hawaii (Dahl 1990). Since the time of European settlement, the conterminous U.S. has lost an estimated 53-55 percent of its original wetlands. By the 1980's, twenty-two states had lost 50 percent or more of historic wetland area (Figure 1).

The causes of wetland loss are numerous and some are deeply ingrained in U.S. attitudes toward wetlands and land use. Early settlers were encouraged to explore and tame the vast wilderness. Wetlands presented natural barriers to what was considered productive land use (i.e., for food or fiber). Many values

associated with wetlands in more recent times were largely unrecognized.

Through a variety of legislative and policy instruments, the U.S. Federal Government encouraged land drainage and reclamation. It was not until the 1970's that serious consideration was given to eliminating incentives and other mechanisms that had made it technically and economically feasible to destroy wetlands (see below).

While the national decline in wetlands is dramatic, losses in particular regions and states are even more startling. California, for example, has lost over 90 percent of its original wetlands (Heitmeyer et al., 1989). In the mid-western farm belt, the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio and Wisconsin have lost over 36 million acres (15 million ha). Virtually all wetlands have been eliminated in the East-Central and Big Prairie Regions, and on the Green River Watershed of Illinois. Nebraska's Rainwater Basin has lost 78 percent of its original wetland acreage. Less than half of the 2.1 million acres (850,000 ha) of Florida's Everglades survive, and the Prairie Pothole Region of Minnesota, South Dakota, and North Dakota has

sustained drastic losses since that region was settled in the 1850's.

The most recent estimates of wetland losses indicate that as of the mid-1980's, the conterminous U.S. was losing wetlands at the rate of 290,000 acres (117,000 ha) per year (Dahl and Johnson 1991). While this estimate reflects a lower rate of loss than documented for previous time frames, reasons for concern remain. The most obvious of these is that wetlands continue to be destroyed by land development activities. Equally as alarming is the rate at which certain wetland types are being altered (Figure 2).

Small temporarily or seasonally flooded wetlands have been severely reduced over time because they are easily drained. These wetlands play a critical role in providing habitat as part of larger wetland complexes. Habitat used by Marbled Godwits is a good example of the importance of diverse prairie wetland complexes. Godwits prefer shallow ephemeral and alkali wetlands during the breeding season, but a mosaic of these types, including semi-permanent and temporary wetlands and associated grasslands, are necessary to satisfy all the habitat needs of

this species (Ryan et al. 1984). Differential loss of the less permanent wetland types, ephemeral and temporary basins, eliminates godwit breeding potential. Likewise, King Rail and Black Rail nest in the driest sites of all rallids, and these species have been most affected by drainage and conversion of habitats to agriculture (Fredrickson and Reid, 1986). Although these areas dry out by midsummer, the presence of ephemeral or temporary water stimulates high waterfowl production by the establishment of territories by breeding pairs and by providing an abundance of invertebrates on which dabbling ducks feed.

Wetlands or wetland margins that are less wet (i.e., wet meadows) also have suffered losses because of encroachment by intensive land use. Complete or partial drainage of wetlands occurs when agricultural or construction activities destroy vegetation along the marsh edges or on the higher contour of a wetland basin. This seriously reduces bird use and can impact other wetland functions.

The "no net loss" concept, as originally recommended by the report of the National Wetlands Policy Forum (Conservation Foundation, 1988) was intended to greatly reduce acreage losses

and to ensure that unavoidable losses would be offset by wetland restoration or creation efforts. Unfortunately, when the policy was developed, there was little recognition of where and how wetland losses were occurring. Several key states with large historic wetland bases dominate loss trends (Table 1). Failure to achieve "no net loss" in these states has hampered the national "no net loss" policy implementation.

Wetland losses typically have been greatest where wetland abundance is greatest (Alaska being a notable exception, Figure 3). Generally, potential conflict with land development activities are more prevalent in those regions. Consequently, any future losses will probably be greatest in the areas where an abundance of wetlands and high potential for land use conversions overlap. Five regions of great wetland abundance and imminent threat include: 1) mid-Atlantic states; 2) Southeastern coastal plain; 3) Great Lakes States; 4) Lower Mississippi Alluvial Valley; and 5) Prairie Pothole Region (Figure 4).

Unfortunately, areas of wetland concentration continue to experience intense land development pressure (Figure 5). One barometer used to help measure land use changes and the potential

for land use conflict is human population change. Of the eleven states whose population is expected to increase by 600,000 or more, seven (Florida, Georgia, North Carolina, Virginia, Maryland, New Jersey and South Carolina) contain abundant wetlands and form much of the Atlantic Flyway (Table 2).

Wetland losses have had an untold effect on environmental quality. Great flooding of the Upper Mississippi River system in 1993 likely was exacerbated by decades of land drainage, levee construction, and other alterations of the hydrologic regime in that region. It is important to understand that the loss of wetlands not only destroys the specific local sites, but also fragments remaining habitats and disrupts wildlife corridors. Most wetlands occur in functional complexes and the destruction of one site effects the functioning of other wetlands within the complex.

C. WETLAND DEGRADATION

Most of the remaining wetlands in North America (except for certain northern latitude sites) that are extant nonetheless have still been degraded; pristine areas are rare. Most degradation has occurred because of changes in the natural hydrology,

vegetation, or water quality of a site or a region. These changes disrupt the controls and influences of the water cycle on food chains, flow of nutrients, etc. The effects of these alterations trickle down throughout the ecosystem, impacting habitat quality and waterbird populations.

Non-hydrological degradation include contamination, resource extraction, (e.g. silviculture, grazing, burning, peat mining, etc.), and disturbance. Contamination is especially acute in some areas and occurs primarily through discharge from residential, agricultural and industrial sources. Organic (including pesticides, polychlorinated biphenyl, and petroleum-related products) and inorganic pollutants (e.g., cadmium [Cd], chromium [Cr], copper [Cu], lead [Pb], mercury [Hg], selenium [Se], and zinc [Zn]) may be transported in dissolved or suspended form or adsorbed to organic or inorganic particulates. Chemicals transported with particulates often remain in sediments for long periods. Remobilization may occur through physical resuspension and transport of contaminated sediments, chemical transformation to soluble forms, or accumulation by aquatic plants and animals that are part of the food chain for waterbirds.

Although no wetland-associated bird species in North America is presently known to be at imminent risk of extinction because of environmental contaminants, species such as the eastern Brown Pelican (*Pelecanus occidentalis*), Peregrine Falcon (*Falco peregrinus*), and Bald Eagle (*Haliaeetus leucocephalus*) formerly were at risk from contaminants but have since recovered (Hickey 1969, Anderson et al. 1975, Cade et al. 1988). Conversely, numbers of individuals (and in some cases entire populations) are seriously affected by contaminants, either through direct mortality, decreased reproductive success, or degradation of foods. Major groups of contaminants in wetlands that affect birds include petroleum, trace elements, acid deposition, organochlorines, and organophosphorus and carbamate insecticides (Parnell et al. 1988).

Waterbirds are affected by petroleum through external oiling, ingestion, egg oiling, and habitat degradation (Ohlendorf et al. 1978; Fry and Lowenstine 1982; Fry et al. 1985, 1986; Albers 1991; Burger and Fry 1993). Trace elements, including Cd, Pb, Hg and Se, are often serious contaminants in wetlands (Scheuhammer 1987; Eisler 1985a, 1985b, 1987, 1988). Lead

deposition in wetlands puts aquatic birds at risk. In frequently hunted areas waterbirds, especially waterfowl, consumed spent lead shot and avian predators and scavengers eat birds not retrieved by hunters. Ingestion of spent Pb shot pellets still is a concern at several sites throughout the United States where the combination of historic high hunting use, hard substrate, and shallow water exists (Hohman et al. 1990, Custer and Hohman 1994). Near smelters, refineries, and Pb battery recycling plants birds are also exposed to waste lead (Eisler 1988).

Although toxic effects from metal ingestion seems to be an unlikely consequence of wetland acidification, the adverse effect of low pH on the occurrence of crustaceans and mollusks could threaten avian egg production and development of young (Albers and Camardese 1993a, 1993b). Lowered pH as a result of acid deposition is one of several possible factors contributing to the decline of certain waterbird populations in North America. Lowered food production on artificially acidified wetlands impairs Black Duck (*Anas rubripes*) duckling growth, condition, and survival (Haramis and Chu 1987, Rattner et al. 1987).

Except for isolated hot-spots, concentrations of DDE have decreased in wetland birds throughout North America (e.g., Custer et al. 1983, Henny et al. 1985, Custer and Mitchell 1987, Weseloh et al. 1989). Elevated concentrations of DDE, associated with decreased reproductive success have been found in White-faced Ibis (*Plegadis chihi*) eggs at Carson Lake, NV (Henny and Herron 1989), and Black-crowned Night-Heron (*Nycticorax nycticorax*) and Great Egret (*Casmerodius albus*) eggs collected from the Salton Sea, CA (Ohlendorf and Marois 1990).

Polychlorinated biphenyls (PCBs) and related organochlorine compounds have been associated with lowered waterbird reproduction. Lowered productivity of Great Lakes fish-eating birds, including Double-crested Cormorants (*Phalacrocorax auritus*) and Forster's Terns (*Sterna fosteri*), was highly correlated with PCB toxicity (Kubiak et al. 1989, Tillitt et al. 1992, Hoffman et al. 1993). After a wetland in central Arkansas was contaminated with polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans from pulp-paper mills, hatching success of Wood Ducks (*Aix sponsa*) was suppressed at sites up to

58 km downstream from the pollution source (White and Seginak 1994).

Most insecticides presently used within the Prairie Pothole region are organophosphorus and carbamate insecticides (Grue et al. 1988). The potential for these agricultural chemicals to enter prairie wetlands and affect reproduction and survival of waterbirds is great. When non-target areas are sprayed or receive drift of insecticides, wildlife may be poisoned directly or may suffer indirect adverse effects, such as increased susceptibility to predators, change in reproductive behavior, or reduced invertebrate prey availability (Brewer et al. 1988, Grue et al. 1988, Tome et al. 1991).

In addition to contamination, there are several other ways by which habitat degradation can occur. Changes in topography, vegetation, hydrology, species assemblages (invasion by exotics), extractions, and disturbance are all important factors that can degrade habitats. Certain management methods may also unintentionally degrade wetlands, especially if artificial hydrological changes are persistent.

Mankind's ability to reverse alterations depends upon a variety of factors, including hydrology, wetland type, location, and productivity. Reversing degradation is often difficult for certain wetland types, such as mangroves.

III. EFFECTS OF WETLAND LOSS AND DEGRADATION ON BIRDS AND BIRD POPULATIONS

Although it is well documented that wetlands provide essential breeding, migration and wintering habitats for many species of birds, few comprehensive studies are available that correlate large-scale wetland loss and degradation with decreased bird populations (Shaw and Fredine 1955; Bellrose 1979; Smith et al. 1989). The following sections provide summaries of the effects of wetland loss and degradation on selected wetland-associated bird groups.

A. SHOREBIRDS

Most western hemisphere shorebird species use wetlands during one or more major periods of the year (breeding, migration, non-breeding). How wetland losses have affected shorebird populations is not easily determined. Key questions are: (1) What are population sizes, and how have they changed?;

(2) Have changes been brought through habitat loss alone or in combination with other factors (global warming, excessive gunning, pollution, etc.)?; and (3) Have changes been entirely due to some other factors?

Wetland losses in North America are well documented (see above), but extensive losses, albeit less well documented, have also occurred in South and Central America, especially in grassland and coastal ecosystems. Accepting that extensive and relatively pervasive wetland loss has occurred throughout North, Central, and South America, except perhaps in Arctic ecosystems, it is important to examine how wetland loss has influenced shorebird populations during the breeding, migration, and wintering phases of their annual cycle.

With the exception of a few scarce and endangered species, population sizes of most North American shorebirds are poorly known. Morrison and Ross (1989) suggest that the non-breeding Semipalmated Sandpiper (Calidris pusilla) population in South America is on the order of 2 million birds. Page and Gill (1994) estimate the North American population size of the Pacific race of the Dunlin (Calidris alpina) to be about half a million birds

and the Marbled Godwit population to be fewer than 200,000 birds. Based on mark/recapture studies, Harrington (unpublished) estimated that the North American Red Knot (Calidris canutus) adult population is on the order of 200,000 ± 100,000 birds. Aerial survey data from South America (Morrison and Ross 1989) suggest a Hudsonian Godwit (Limosa haemastica) wintering population on the order of 50,000 birds. Handel and Gill (1992) estimate the Black Turnstone population at 61,000 - 99,000 adults, and speculate that the Surfbird (Aphriza virgata) population size 50,000 - 70,000 (in Norton et al. 1990). Estimates of the Western Sandpiper (Calidris mauri) population are in the low millions (Butler and Kaiser, 1988). These crude figures suggest that the populations of some of the most abundant North American shorebirds, (i.e., Semipalmated and Western Sandpiper) are in the low millions, and in the tens or hundreds of thousands for less common species which are not considered threatened (i.e., Red Knots, Marbled Godwits, Black Turnstones, and Hudsonian Godwits).

Although shorebirds may be quite abundant at specific sites (Morrison and Harrington, 1979; Myers et al. 1987), their overall

populations appear to be quite small in comparison to many other avian groups. With the exception of the Red Knot, there are no error estimates for the population values given above. Current population estimates are crude and of limited value for tracking population change, except in the event of very drastic changes. Similarly, recent efforts to track population trends from data in the International Shorebird Surveys lacked robustness; changes of more than fifty percent were typically required before statistically tests were significant (Howe et al. 1989). Nevertheless, population declines were detected for three of 12 species monitored between 1974 and 1982. The cause(s) of these changes are unknown.

For historic comparison, it is commonly claimed that shorebirds in North America were nearly annihilated by sport and market gunning during the late 19th century (Banks 1977, Forbush 1912, Stout 1969). Virtually none of these early publications provide useful numbers for comparison with numbers today. Statements such as "hundreds of thousands in clouds darkening the skies" were used in the earlier works for embellishment purposes and not for numerical guidance, although there are some useful

exceptions. Audubon (in Stout 1969), conservatively estimated 48,000 Golden Plovers were shot in a single day. We know of no comparable counts (even of live birds) in modern times. Over 12,000 shorebirds were sold in the San Francisco market during the 1895-96 season (Skinner 1962). Mackay (1893) tells of 7,000 Golden Plovers being delivered to a Boston market, a number that would also be extraordinary anywhere today. Mackay (1893) describes barrels of Red Knots being sent to Boston during spring; if the 'barrels' were the standard barrel of the day, then roughly 4,000 knots were involved on these transactions. Counts of even 500 knots during spring in Massachusetts would be extraordinary today.

Despite a lack of information on past or present abundance of shorebirds, we believe (see also Forbush 1912) that shorebird populations were once much higher than they are today. Many species were reduced by market and sport gunning to a point where populations were in peril; most (but clearly not all) have substantially recovered since then. A look at these 'recovery' patterns provides evidence of how habitat loss may have affected some populations.

We divided the common breeding shorebirds of North America into geographic and habitat groupings (Table 3). We assigned a relative abundance ranking for each species between 1 (abundant) and 6 (nearly extinct), using information from the International Shorebird Survey files (Manomet Observatory, unpublished), the Pacific Flyway Project (Point Reyes Bird Observatory, unpublished), and South American aerial shorebird surveys (Morrison and Ross 1989). Using descriptions given by Forbush (1912), the relative abundance prior to 1875 and again for about 1910 was ranked.

Comparison of rank values from pre-1875 with the current rankings suggests that one "habitat guild" of shorebirds, the temperate beach-nesting species, have not regained historic population abundance since shorebird gunning became illegal under the Migratory Bird Treaty Act in 1918. Other temperate-breeding species appear to have recovered substantially, even though some now have shrunken breeding ranges (Page and Gill 1994). Although most of the more northern-breeding shorebird populations have recovered, exceptions exist for Purple Sandpipers, Lesser Golden Plovers, Eskimo Curlew, and Red Knots (Table 3). We question the

difference for the Purple Sandpiper doubting that it ever was as common as Forbush's (1912) comments suggest. As for the Lesser Golden Plover, it is clear that extensive loss of its wintering grassland habitats to agriculture has occurred in Argentina, Uruguay and southern Brazil (Blanco et al. 1994). There also has been virtual annihilation of the Louisiana and midwestern US prairie habitat that Golden Plovers formerly used during spring migration.

The formerly abundant Eskimo Curlew is now virtually extinct; it used many of the same habitats as Golden Plover during winter and migration (Gollop et al. 1986). It is unclear whether habitat loss, overharvest, or other causes (e.g., see Banks 1977) are responsible for the decline (Blanco et al. 1994). Red Knots also are less common today than prior to 1875; cause(s) for this are unclear as well, but are unlikely to be related to loss of breeding habitats. During spring migration, the principal food of Red Knots at major migration staging areas in the U.S. is Horseshoe Crab (*Limulus polyphemus*) eggs (Mackay 1893, Harrington 1986). There is little documentation of what effect the intensive harvesting of Horseshoe Crabs (for fertilizer) had either on crab

populations or its predators such as Red Knots. It appears, however, that favored habitats of knots at the most important spring staging areas (Cape Cod Bay in the 1800s, Delaware Bay today) remain essentially intact.

The relative abundance of some other species listed in Table 3 appears to have declined by one rank since the mid-1800s. We do not consider these differences sufficiently precise to be confident that they are meaningful.

In summary, the scanty historic record indicates that habitat loss has affected population sizes of temperate zone beach-nesting shorebirds and the breeding ranges of some other temperate nesters have shrunk, but there is not clear evidence that populations of most northern-breeding species have declined. Current studies looking at effects of habitat loss recent years do, however, show close relationships between habitat availability and shorebird densities at breeding (Hötker 1991), wintering (Goss-Custard 1979, Evans and Pienkowski 1983), and migration staging areas (Lambeck et al. 1989, Evans et al. 1991).

Data collected for the International Shorebird Survey and the Pacific Flyway Project, and winter aerial shorebirds surveys

on the South American coast (Morrison and Ross 1989) and parts of the Mexican coast show that migrant and wintering shorebirds are not evenly distributed within their normal ranges (MBO and PRBO, Unpubl. data). In the case of some species, distributional clumping exists to such a degree that a substantial fraction of a species' population could be present in a single bay or wetland area on a single date or series of dates. This extreme clustering places a large fraction of a population to simultaneous risk of catastrophe. Sufficient information is not available to determine whether this is a historic situation, but it is probable that extreme clumping is at least in part created by loss of suitable habitat alternatives. In some major shorebird migration zones, up to eighty percent of traditional wetland habitats have been destroyed since European settlement of North America.

Using International Shorebird Survey data, Harrington (Figure 1) compared the relative clustering of arctic-breeding shorebirds at 210 and 457 migration areas censused during spring migration and autumn migration respectively. There was highly variable clumping with respect to both species and season, suggesting that some shorebird populations were vulnerable to

loss of strategic wetland sites. Future conservation efforts need to focus on protecting strategic sites while at the same time restoring alternative sites as a way of reducing risks (Myers et al. 1987).

B. WATERFOWL

No family of waterbirds has been more investigated in relation to distribution, population dynamics, and habitat use of wetlands than the anatids. Ducks, geese, and swans display the greatest diversity of species found in any single waterbird family (some 160 species worldwide, nearly 60 species in North America). This group of species uses a wide variety of wetlands, but palustrine-forested, palustrine- emergent, riverine and estuarine are among the most important habitats across the annual cycle events.

Breeding ground surveys were begun in 1946 and standardized techniques for counts with aircraft were established by 1955. Wetland data has been systematically collected across northern prairie breeding grounds since 1961. Emphasizing wetland habitats in the prairies, parklands, and boreal forests of the United States and Canada, few continental avian population

surveys have been so extensive as the waterfowl surveys over the last forty years. Collected data include wetland counts in May and July and breeding pair and brood numbers. These large spatial scale data sets indicate regularly fluctuating patterns in emergent wetland flooding and corresponding population changes of several duck species. An obvious, yet complex, relationship exists between habitat quantity and quality and waterfowl population densities. Such large spatial surveys provide unique data sets for long-term investigations. Satellite data now afford the ability to quantify habitat change in temperate and arctic wetland environments.

Several measures of waterfowl survival, recruitment, movements, and relative distribution are directly correlated with abundance, distribution, type, and quality of wetlands. Successful breeding ducks may return to wetland complexes in successive years. Successful adult female mallards returned to breeding areas in North Dakota at a rate of 0.77 compared to 0.35 for unsuccessful, inexperienced young mallards (Lokemoen et al. 1990). Older female mallards tend to reach the breeding grounds in better condition, arrive earlier, lay larger clutches, and

fledge more young than young females (Cowardin et al. 1985). Distribution of breeding northern pintail populations is correlated positively with spring wetland conditions on the prairies (Raveling and Heitmeyer 1989), and the number of pintails was correlated more strongly with May pond numbers (R2 = 0.56) than any other duck species (Johnson and Grier 1988). When conditions on the prairies are dry, pintails fly to high latitude wetlands of arctic Alaska and Siberia, where nesting effort is thought to be low (Derksen and Eldridge 1980). Habitat conditions influence pair selection of breeding ponds, hen and nest survival, and young fledging. Mallard young survived at higher rates in high density pothole complexes in Manitoba, than in poorer quality habitat (Rotella and Ratti 1992). Complexes of ephemeral, seasonal, and semi-permanent wetlands, intermixed with grass-dominated areas of the prairies produce higher fledging rates than modified landscapes dominated by crop-land wetland complexes (Klett et al. 1988).

Loss and degradation of wetlands and associated uplands have been responsible for the decline of many waterfowl species over the last four decades (Tiner 1984, Smith et al. 1989). In the

mid-1800s, an estimated 2 million ha of wetlands were present in California, and as recently as the 1970s, an estimated 10-12 million ducks, geese, and swans wintered in, or migrated through this region (Heitmeyer et al. 1989). By the mid 1980s, less than 200,000 ha of wetlands and 4 million wintering waterfowl remained. Owens Lake of the eastern Sierra, which once held hundreds of thousands to millions of migrating waterfowl, has been totally drained for urban water use in the Los Angeles basin. Degradation of water quality in Chesapeake Bay during the 1960s and 1970s caused declines in submerged aquatic vegetation and corresponding declines in numbers of wintering redheads and canvasbacks. Loss of wetlands has occurred across critical breeding, migration and wintering habitats.

Perhaps a greater challenge to waterfowl management than wetland loss is continued habitat degradation through hydrologic alteration of watersheds. Modifications to flooding cycles result in hydrologic stabilization, shifts in flood timing, and increased or decreased flooding (Klimas 1988). Modification of natural flood chronology and periodicity ultimately reduces long-term productivity of wetlands, limiting habitat availability and

resulting in a decline of waterbird use (Fredrickson and Reid 1990).

In addition to the direct impacts of wetland loss or degradation waterfowl effects may be indirect and may involve predator community changes. Intensive farming practices have concentrated duck nests and reduced availability of alternative prey for waterfowl predators. Waterfowl nests in the prairie and parkland regions are in the remaining untilled habitats where predators concentrate foraging activities (Cowardin et al. 1985). Human-inflicted mortality on predators, interspecific predator interactions, and habitat changes in the northern great plains have caused significant changes in species composition and abundance of predators. For example, populations of Red Fox, Raccoon, Coyote and American Crow, which prey extensively on nesting waterfowl or their eggs, have greatly expanded in the prairie region since the 1960's (Sargeant et al. 1984). In several regions of the prairies, because of high hen and nest mortality, waterfowl recruitment levels have been below rates needed to sustain populations.

To take advantage of seasonally available resources, most waterfowl have adapted long-distance migrations between wetland complexes. Acquisition of food during migration is critical because birds must obtain substantial nutrients in a short period to sustain migration and store body reserves for other productive processes including reproduction. Body condition on departure from wintering and spring staging areas may be the critical factor limiting reproductive output (Drent and Daan 1980). This is especially true for large-bodied ducks, swans, and geese (Ankney and MacInnes 1978, Raveling 1979, Alisauskas and Ankney 1985). The documented relationships between waterfowl populations and wetlands may be used to predict effects on other birds that use similar locations, wetland types, and resources.

Cross-seasonal effects of wetland conditions have been recognized for mallards (Heitmeyer and Fredrickson 1981, Kaminski and Gleusing 1987) where both winter wetland conditions in the lower Mississippi Alluvial Valley and spring wetland conditions in the prairie pothole wetlands influence recruitment that summer. Relationships have also been identified for spring wetland conditions on the prairies, winter wetland conditions in

the Central Valley of California and northern pintail recruitment (Raveling and Heitmeyer 1989). Evidence suggests that pintail recruitment (as measured by age-ratio harvest) was most related to breeding habitat conditions when spring seasons were dry and populations small, but age-ratios were most related to winter habitat conditions the previous year when followed by wet spring seasons and very large population sizes (Raveling and Heitmeyer 1989).

Numerous wetland conservation and management programs have focused on waterfowl conservation (e.g., Canadian Wildlife Service and U.S. Fish and Wildlife Service 1986, Ducks Unlimited 1994) and each identifies primary areas where habitat protection and restoration are most needed. While the long-term ecological efficacy of many programs is still unknown, the immediate effects seem to act best when management regimes emulate natural hydrologic cycles and functions.

C. COLONIAL WATERBIRDS

The history of wetland changes and their influence on colonial waterbird populations has been documented for a number of areas in the United States (e.g., Graber et al. 1978, Ogden

1978, Erwin 1979, 1995, Kushlan 1989, Kushlan and Frohring 1986; Carter et al. 1995). As for shorebirds, however, accurately estimating pre-1960 populations of any bird species over large areas is difficult. Population trend analyses for changes occurring between 1940-1970, when wetland losses were greatest, are therefore somewhat speculative (Frohring et al. 1988). Even so, vast changes have occurred in some areas of the U.S.

Loss of bottomland hardwood forests in the southeastern U.S. and along the Mississippi River and its tributaries has affected a variety of species (U.S. Dept. of Interior and Environment Canada, 1986; Erwin, in press). Although population data before 1960 are limited, the conversion of forested wetlands to agricultural crops has displaced a number of colonial nesting species such as Great Blue Herons (Ardea herodias), Great Egrets, and Black-crowned Night-Herons (Graber et al. 1978, Thompson 1979). Similarly, loss of mangroves in the Florida Keys due to development may have displaced colonies of Reddish Egrets (Egretta rufescens) and Roseate Spoonbills (Ajaia ajaja), two "species of concern" (Office of Migratory Bird Management 1987).

Agriculture is one of the largest contributors to wetland loss and habitat degradation for colonial waterbirds (MacDonald et al. 1979). Altered hydrology and diversions of water for agriculture have caused major declines of many wading birds in south Florida, including Wood Storks (Mycteria americana) and White Ibises (Eudocimus albus) (Kushlan and Frohring 1986, Bancroft 1989, Kushlan 1989, Davis and Ogden 1994). Wood Stork populations apparently have shifted north into Georgia and South Carolina (Ogden et al. 1987). Although not as dramatic as in the Everglades, changes in regional hydrology have influenced waterbird distribution in other states including Louisiana, Texas, and Georgia. In the Prairie Pothole region, intensive farming has drained numerous small wetlands, especially less permanent types (Aus 1969). Although the effect has been most dramatic on waterfowl (Aus 1969; Ratella and Ratti 1992), numbers of Franklin's Gulls (Larus pipixcan) and Forster's Terns (Sterna forsteri) have also declined as colony sites became more limited (Knopf, 1994).

Levee and dam construction along major river systems for flood control and agriculture has had major impacts on fish and

wildlife resources. Changes in flooding frequencies and hydrology of rivers such as the Platte, Missouri, and other tributaries of the Mississippi, have altered nest-site availability for the endangered interior populations of the Least Tern (Sterna antillarum athalossos), and the threatened Piping Plover (Charadrius melodus) (Kirsch 1992, Sidle et al. 1992). The impact of such drastic changes to local and regional forage fish populations, while unknown, is likely substantial.

Growing human populations in coastal regions have removed and modified barrier beach habitat (both uplands and wetlands) along much of the Atlantic and Gulf Coasts (Bildstein et al. 1991); this in turn has affected several species of terns and Black Skimmers (Rynchops niger) forcing them to nest on rooftops or manmade islands (Erwin 1979, 1980). Filling marshes behind barrier dunes for marina development and vacation homes has resulted in substantial habitat losses for shellfish and finfish as well as waterbirds (Chabreck 1988). Wetlands created to treat municipal wastewater have attracted colonial wading birds and other species. In Florida, fish collected from such lagoons carry

very high loads of nematodes (*Eustrongylides* spp.), which are frequently fatal to wading birds (Spalding et al. 1993).

In general, few conservation or management activities have been planned for non-waterfowl waterbirds, exceptions including the protection of colony sites and some water level management for wading birds and rails. In most cases, the ecological effects of these activities are not well documented.

D. THREATENED AND ENDANGERED SPECIES

As with other non-waterfowl species, few data are available on population levels or even basic biology of some rare, secretive, or less known wetland-associated species. The diversity of birds that use wetlands is large. Many species may use wetlands for only a short period during the annual cycle, but these periods may be critical for acquisition of key resources. These species include many neotropical migrants, such as warblers, flycatchers, thrushes, etc.

As mentioned above, many threatened and endangered bird species are highly dependent on wetlands. Usually, the severe decline of wetland associated threatened and endangered bird species is at least partly caused by destruction, degradation,

and fragmentation of the wetland types on which they depend. In many cases, a fundamental break in the food web is involved.

The proximal causes of wetland loss and degradation on populations of threatened and endangered species are varied. In the Prairie Pothole region, the Alkali Lakes region, and the Large Saline Lakes of the west, for example, drainage problems for agricultural purposes affect invertebrate availability; species affected include California and Yuma Clapper Rail, Whooping Crane, and Piping Plovers.

Once a species becomes rare, a variety of seemingly unimportant and unpredictable effects can be very serious: Piping Plover chicks, for example, fall in cattle tracks and die. In the case of freshwater marshes, the loss of snags, perches, and nest sites have affected Bald Eagles, Ospreys, and Peregrine Falcons.

Loss of habitat has undoubtedly caused the decline of the Clapper Rail. It is well documented that certain water management regimes affect food availability for Snail Kites and Wood Storks. The loss of wetlands in Hawaii, coupled with the introduction of exotic species, has caused the decline of the Hawaiian Duck,

Hawaiian Coot, Hawaiian Gallinule, and the Hawaiian Stilt (Engilis and Pratt 1993).

The loss of forested wetlands through logging and subsequent drainage destroyed bald cypress (Taxodium distichus) trees used for nesting Wood Stork and Ivory-billed Woodpecker, Mississippi Sandhill Crane, and Bachman's Warbler. Golf course development today is an important force behind the loss of the remaining tracts of this type of wetlands.

In the case of tidally-influenced wetlands, the loss of salt marshes caused the decline of the Seaside Sparrows. The loss of mangroves caused the decline of the Yellow-shouldered Blackbird; and industrial pollution adds to the decline of the California Least Tern.

In general, most management of threatened and endangered species has sought to protect the remaining key wetland sites. Active management to allow for population recovery is much more rare.

E. POSITIVE ASPECTS OF WETLAND CHANGES UPON WATERBIRDS

Not all wetland changes over the past few decades have negatively affected birds. Some changes have enhanced breeding

and/or feeding habitats for certain species, although the overall effect on environmental quality is, in most cases, negative.

A few specific cases highlight certain alterations that benefited bird populations. Although it is important to recognize these benefits, we do not suggest that these benefits necessarily outweigh environmental costs.

Changing narrow river corridors to large reservoirs has drastically altered the wetland profile (Mitsch and Gosselink 1993) and affected numerous wildlife species. For wading birds such as the Great Blue Heron and Great Egret, more feeding habitat has been created (Bildstein et al. 1994). For Double-crested Cormorants (Phalacrocorax auritus), large reservoir creation with islands or snags for nesting may have provided opportunities for recent rapid population increases (Hatch 1995).

Many federal and state wildlife agencies impound freshwater, brackish, or salt marshes or forested wetlands ("greentree reservoirs") primarily to enhance feeding conditions for migrating and wintering waterfowl (Fredrickson and Taylor 1982, Fredrickson and Bitema 1992, Chabreck 1988). The creation of large, shallow water areas provides important feeding habitat for

many species of wading birds, shorebirds, and waterfowl where these systems attempt to mimic regional hydrology and alter flooding regimes among years, productivity of seasonal wetlands can remain high (Epstein and Joyner 1988, Helmers 1992, Reid 1993).

Along intercoastal waterways and in major shipping channels in the Mississippi River, the Great Lakes and elsewhere, maintenance dredging of channels requires dredged material to be deposited, in many cases as islands. Such sites attract colonies of terns, gulls, and wading birds (Soots and Landin 1978). Dredge islands are especially attractive to nesting birds where natural beach areas are developed or highly disturbed (Erwin 1980).

The creation of catfish and crayfish farms in Mississippi, Louisiana, and other parts of the southern U.S. has attracted large numbers of wintering Double-crested Cormorants, Great Blue Herons, White Ibises, and other fish-eating birds (Nettleship and Duffy 1995; Fleury, Louisiana State Univ., unpubl. data). Concentrated winter resources may have facilitated rapid population increases of cormorants across much of the eastern U.S. and Canada (Hatch 1995).

Creating or restoring wetlands to replace or mitigate those lost during development projects has raised many ecological concerns (Brinson and Lee 1989). As feeding generalists, many wading bird species use a variety of created wetlands including municipal wastewater treatment sites, mining restoration sites, highway mitigation wetlands, and others (Edelson and Collopy 1990). Under conditions of drought or where alternative sites are limited, created wetlands may benefit waterbirds by buffering prey declines in natural habitats.

Creating high saltmarsh ponds and ditches for mosquito control originated in New Jersey in the 1950s and is now practiced from Massachusetts to Florida (Ferrigno and Jobbins 1968). As with wetland mitigation, many questions remain about the overall ecological implications of the practice (Whigham et al. 1982). A number of studies, however, have documented increased use by colonial waterbirds, shorebirds, and waterfowl on ponds and ditches created for mosquito control (Meredith and Saveikis 1987, Erwin et al. 1991, 1994). Whether this increased use reflects redistribution, or actual population increases, is unknown.

IV. WETLAND CONSERVATION PROGRAMS

A. WETLAND POLICIES: PAST AND PRESENT

Numerous human activities have caused the draining, filling, flooding, and degradation of wetlands and riparian habitats. Agriculture, dams and flood control projects, road building, urban development, pollution discharges, groundwater pumping, and deforestation have all taken their toll on the amount and quality of wetlands in North America. Most wetland degradation occurs as a result of changes to the land base, primarily due to agriculture. Depletion, diversion, and contamination of the water that supply wetland and riparian habitats is an increasing problem especially in arid western areas.

Because most problems have been caused by altered land uses, wetland protection policies have focused on reducing, regulating, and mitigating public and private land uses. In addition, efforts have been made to protect critical wetland habitats via land acquisitions, conservation easements, and establishment of refuges and wilderness areas. Policies that protect water supplies for wetlands have gained increasing attention in the last fifteen years. Support for policies that go beyond mere

protection to restoration of wetlands is growing, and will be a focal point for debate in the upcoming years.

Federal legislation in the early 1800s followed the same resource-extractive policies used during colonialism to promote land and resource development. Land grants were given to colonists in the eastern U.S., and the gifts were repeated in the midwest, southwest, and western U.S. by the enactment of the Swamplands Act of 1849, the Homestead Act of 1862, the Desert Lands Act of 1877, and others. These acts promoted settlement of new territories by giving away land rights in exchange for proof of development (White 1969, Gottlieb 1988).

The U.S. Army Corps of Engineers was established in 1802 as the government's primary construction agency for military and civilian works ranging from construction of the Erie Canal to navigation channels in the Mississippi River. The Flood Control Act of 1936 assigned primary responsibility for flood control on major streams to the Corps, increasing its reach and budget authority. Based on this Act, and others that followed, the Corps has constructed more than 10,000 miles of levees and channel improvements at a cost of more than $20 billion. These activities

have contributed to the loss of millions of acres of wetlands in the lower 48 states.

The Reclamation Act of 1902 created the U.S. Bureau of Reclamation, the agency responsible for building irrigation and power projects in the western U.S. Bureau of Reclamation projects include 355 reservoirs, 254 diversion dams, and thousands of miles of canals and drains to irrigate more than 9 million acres of arid lands at a cost of almost $10 billion, about 85% of which is subsidized by the federal government (Wahl 1989, U.S. Bureau of Reclamation 1990). These projects have dammed and diverted hundreds of streams, inundated wetlands and riparian habitat, reduced instream flows for fisheries, and produced polluted runoff.

In 1903, the National Wildlife Refuge system was established to protect certain critical habitat areas. The first refuge was the 3-acre Pelican Island in Florida; a bird sanctuary. Today, there are over 500 refuges encompassing approximately 90 million acres, many of which are wetlands (U.S. General Accounting Office, 1987).

New ways of approaching management of water and watershed resources began to emerge at the federal level in the late 1940s, as seen by the passage of the Water Pollution Act of 1948 (establishing a study program and grants for wastewater treatment); the Dingell-Johnson Act of 1950 (to restore freshwater fish); the President's Water Resources Policy Commission of 1950 (reporting on policy reform needs); and the Watershed Protection and Flood Prevention Act of 1954 (to provide technical and financial aid to local communities) (White 1969). The era of broad-based environmental protection began with the enactment of the Wilderness Act of 1964, the Wild and Scenic Rivers Act of 1968, the National Environmental Policy Act of 1969, the Clean Water Act of 1972, and the Endangered Species Act of 1973.

Other state and federal legislation followed, but Section 404 of the Clean Water Act (CWA) provided substantial wetlands protection. Section 404 of the CWA essentially prohibits the dredging or filling of any portion of the 'waters of the United States' without a permit. The U.S. Army Corps of Engineers is the primary permitting agency, while the U.S. Environmental

Protection Agency has final responsibility for promulgating environmental guidelines and has veto power over individual permits. The guidelines require that filling of wetlands be avoided if practicable alternatives are available. The 1977 re-authorization of the CWA expanded wetlands protection by providing for the delegation of the S. 404 program to states and authorizing the National Wetlands Inventory to assist states in developing programs, but exempted farming and silvicultural practices. The U.S. Fish and Wildlife Service, under the Fish and Wildlife Coordination Act, must be consulted on all actions proposed under S. 404 and must prepare a mitigation report should a S. 404 permit be approved, as well as having responsibility for the National Wetlands Survey. In addition, the U.S. Fish and Wildlife Service can designate "critical habitat" for species listed as threatened or endangered under the Endangered Species Act. The National Marine Fisheries Service shares this responsibility for coastal wetlands and for anadromous fisheries (Environmental Defense Fund and World Wildlife Fund, 1992).

Despite the enactment of the CWA, wetlands losses have continued. Efforts to reduce incentives that encourage

agricultural conversion resulted in several programs administered by the U.S. Department of Agriculture's Soil Conservation Service (now Natural Resources Conservation Service). The Food Security Act of 1985 denied federal agricultural benefits to farmers who converted wetlands to agricultural uses. Additionally, the Food Security Act of 1990 established the Wetlands Reserve Program, under which permanent easements on agricultural land are secured for the purpose of restoring wetlands. The Federal Water Bank Program also provides farmers a stipend to keep wetlands out of crop production (Environmental Defense Fund and World Wildlife Fund, 1992, The Conservation Foundation 1988).

Other federal efforts that seek to protect wetlands include Executive Order 11990 (1977) mandating federal agencies to minimize wetlands destruction in their activities; the Emergency Wetlands Resources Act of 1986, giving the Department of the Interior a variety of funding sources for wetland acquisition; and the Water Resources Development Act of 1990, which directs the U.S. Army Corps of Engineers to pursue the goal of "no overall net loss" of wetlands in its water resources development projects. Other federal statutes and agencies that affect

wetlands protection via regulations of federal lands and monies include the Resource Conservation and Recovery Act (addressing contamination issues), Foreclosure Programs, Coastal Zone Management Act, and management of National Forests and Parks.

About 20 states also have wetlands protection programs that are generally consistent with federal statutes and often use the same definitions and guidelines (for a full discussion of federal and state policies see U.S. General Accounting Office 1987, Environmental Defense Fund and World Wildlife Fund 1992, Steiner 1991). States have jurisdiction over a variety of water laws and allocation policies -- a very powerful authority, especially in the arid west. Many states are now recognizing the legal right to use water for fish and wildlife protection purposes, whereas previously water left in the stream was considered "waste to the sea" (MacDonnell et. al. 1989, Moore and Willey 1991). Instream flow water rights are being issued to state agencies (Arizona, California, Oregon, and Washington, among others) and private organizations like The Nature Conservancy in Arizona. Furthermore, efforts to purchase senior water rights to restore wetland and riparian habitats that were degraded by U.S. Bureau

of Reclamation irrigation projects are being implemented via federal legislation such as the Truckee-Carson Water Rights Settlement Act of 1990 and the Central Valley Reform Act of 1992 (Moore and Willey 1991).

Most federal and state programs have jurisdiction over public lands, agencies, and funds; the majority of wetlands (outside of Alaska), however, are privately owned by farmers, ranchers, corporations, land trusts, and other individuals (Conservation Foundation 1988). Therefore, a variety of policies have been established to encourage private landowners to protect wetlands. The basis of efforts to promote private conservation efforts must be public education -- if landowners and the general public are not aware of wetlands' benefits and values they will have no desire to work towards their protection. Many non-profit organizations, such as National Wildlife Federation, National Audubon Society, and Ducks Unlimited, have numerous public education materials that are offered to their members, the general public, the media, and government agencies.

In addition to information, private landowners may need economic incentives to protect wetlands on their properties.

Because wetlands protection has wider public benefits, some public subsidy of the private costs may be justified. At the very least, public subsidy of activities that promote wetlands and riparian habitat destruction should be reduced, such as subsidized grazing fees and subsidized irrigation supplies. Some economic activities can be compatible with wetlands protection, including private habitats managed for fishing, hunting, recreation, and production of blueberries, cranberries, and rice (Conservation Foundation 1988). Other economic incentives for wetlands protection include tax deductions for conservation easements or land donations to trusts or other non-profit organizations. Direct subsidies may be required where the value of the land or the property owner's income are low, in which case the federal Wetlands Reserve Program, the Water Bank, or the Conservation Reserve Program, can provide funds to farmers to keep wetland landscapes out of production.

Land exchange programs between private landowners and public agencies also are possible, whereby privately-owned habitat can be exchanged for public lands less sensitive to development. Such transfers of "the right to develop" are also being experimented

with in innovative and controversial programs to control land uses while continuing to allow development (for further discussion see Tripp and Dudek 1989, Roddewig 1987). In the New Jersey Pinelands, Transferable Development Rights (TDRs) have been used to allow landowners with property in designated preservation areas to sell development credits to developers (Tripp and Dudek 1989). Similar concepts have been used to create "mitigation banks" where wetlands or funds can be contributed to offset negative impacts of development in wetland areas.

Many of the programs designed to encourage private landowners to protect wetlands and riparian habitats depend on local organizations to work with landowners, receive donated lands and funds, handle land exchange deals, and manage transferred rights or mitigation banks.

The "no net loss" goal set in 1988 by the National Wetlands Policy Forum and endorsed by President Bush sought to prevent further erosion of the remaining wetland base. Stemming the tide of loss, however, will not be enough to stabilize endangered species populations in many areas. It is increasingly clear that

restoration of wetlands and riparian habitats will be necessary (National Academy of Sciences 1992).

B. CURRENT IMPLEMENTATION PROGRAMS

Many state, federal, and private entities are actively involved in wetland conservation programs. Few programs, however, are guided by a coordinated ecosystem-oriented strategic plan. Most programs seek to protection of key wetland sites, usually through fee-title acquisition.

Active management and enhancement of wetlands has been undertaken primarily for waterfowl. The effects of these management schemes on non-waterfowl species are believed to be mostly beneficial, but many effects are unknown.

Missouri and Tennessee, however, are two states that have developed wetland management plans that focus on multiple species and an array of wetland types. Missouri has a broad based plan that identifies wetlands by region along with habitat and animal population objectives. Rare, endangered, and exotic plants are an integral part of the plan. Birds are a major focus of the plan, but population objectives extend well beyond the traditional waterfowl approach. Rare, endangered, and threatened species at

the state and national level are included. The Missouri plan also includes objectives for utilization through hunting, viewing, and education. Following the 1993 floods, extensive areas of floodplains have been acquired that help meet the objectives in these regions.

Many organizations and agencies are recognizing the need for "net gains" in wetlands and are promoting restoration. Techniques to restore wetlands in urban, commercial, or urban areas are in an initial stage and attempts to restore certain wetland types have failed. Conversely, restoration of wetlands with modified hydrology in rural environments have often been highly successful when the natural hydrology is emulated. Restoration of modified environments achieve the greatest success when natural hydrological processes can be mimicked as closely as possible within a wetland landscape (Fredrickson and Reid 1990).

One example of a cooperative plan to conserve wetlands is the North American Waterfowl Management Plan (NAWMP). This plan is mostly based on biological needs of a specific waterbird group (waterfowl), and can be a model for, and provide lessons to, other attempts to protect and enhance wetlands. Efforts to

integrate multi-species benefits and ecological values into the NAWMP are ongoing.

C. INTERNATIONAL EFFORTS

Many North American waterbirds migrate to Central and South America each winter, consequently, wetlands conservation outside of the U.S. is critical. Once in the Neotropics, migrant birds face an array of conflicting land use dilemmas. With 8% of the world's human population, (72% of them living in cities), Latin America still offers large areas of relatively untouched habitats (WRI 1990). The Pantanal in Brazil and Bolivia; the Beni in Bolivia; the Llanos of Venezuela; or the Wet Chaco of Argentina and Paraguay, are good examples.

Human population growth is still very rapid, although declining (currently at 1.9% annually for the region as a whole). Habitat alteration typically results from urban and rural development, the type and intensity varying among countries. Urban and tourism development is growing fast in some coastal areas, such as the province of Buenos Aires in Argentina, vast areas of Brazil, and parts of Venezuela, Colombia, and Ecuador. No comprehensive estimations of wetland loss exist for Latin

America, but some partial figures are available. As an example, 25% of Venezuelan wetlands have been lost in the past 20 years by drainage, filling and inundation (Gómez-Dallmeier and Cringan 1989).

Ecuador is the world's leading producer of shrimp. To build shrimp ponds, coastal mangroves are being destroyed constantly. In some provinces, such as Guayas, up to 48.4% of coastal mangroves have been destroyed (Granizo, 1993). Mangrove wetlands are rich in biodiversity, and it is paradoxical that the shrimp industry, which destroys mangroves also depends on healthy mangroves for shrimp larvae development. Expanded shrimp pond development is currently occurring in western Mexico and Nicaragua.

Other wetlands are under growing pressure to be transformed to rice fields. The process is accelerating in southern Brazil, NE Argentina, Suriname, and Uruguay. In Argentina, one of the few remaining portions of native grasslands is the pampas region (Bajos del Salado, Buenos Aires province). This area may disappear soon because of new technology for draining the area and the expansion of *Eucalyptus* forests (J. Amaya, pers. com.).

Large water development projects occur in Latin America and flood valuable wetland and riparian habitats used by various North American migrant birds. Over 885 dams (over 15 m high) are present in South America alone. Of this total, 516 occur in Brazil. The Paraná River, the largest second river in Latin America, already has 23 dams constructed or under construction. Among these, Itaipú is the biggest dam in the world, and Yaciretá has recently been completed.

The Paraná and Paraguay rivers that flow from the Pantanal are under threat by a planned waterway. This may affect the most extensive wetlands in South America, in particular the Gran Pantanal, considered the biggest wetland in the world (140,000 km^2 to 200,000 km^2). This site has a high biodiversity of waterbirds (Bucher et al., 1993).

In spite of the above problems many promising programs are developing in the region. The Western Hemisphere Shorebird Reserve Network (WHSRN), a program of Wetlands for the Americas, is creating a network of protected areas to guarantee the conservation of migratory shorebirds. Currently, 25 sites, from Alaska to Tierra del Fuego in seven different countries, are part

of WHSRN and the number is growing steadily (Hunter et al. 1991; Castro, 1993).

Participation of Latin American countries in the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) has been raising steadily in the last years. More than twenty countries currently are members, and dozens of Wetlands of International Importance have been designated, demonstrating the political interest of these countries in wetland conservation (Jones, 1993).

An annual waterbird census in nine countries of the region is conducted, with national coordinators in each country and an extensive network of volunteers. Since these censuses started in 1990, the number of volunteers and countries has been growing rapidly. A report is published every year with bird numbers and distribution (Blanco et al. 1994).

On a broader context, there are 162 protected wetland areas or 10.27% of the territory in Central America. In Mexico, 65 areas are protected covering 3% of the territory; and 667 protected areas cover 5.5% of the land area in South America (Barzetti 1993). Clearly, concern for conservation has grown

enormously in the last years, and an important portion of the region is now under some legal form of protected area. Another important trend in the region is a system of private reserves growing rapidly in some countries, such as in Argentina.

There are good experiences in the sustainable use of wetland wildlife in South America, including the Capybara (*Hydrochaeris hydrochaeris*), Caiman (*Crocodylus intermedious*) and River Turtle (*Podocnemis expansa*) (Bucher, 1989). These managed harvest regimes support wetland conservation while providing economic alternatives to rural communities.

In the Huanchaco Extractive Reserve in coastal Perú, fibers from *Typha* have been in use for more than 1,500 years to construct fishing vessels. Wetlands are protected by local communities in order to protect *Typha*. In Costa Rica, the IUCN is managing successfully a mangrove extractive reserve in Terraba Sierpe, with coal and wood production ensured in a sustainable way.

The existence of large areas of suitable habitat still in a relatively undisturbed condition offers unique opportunities for developing conservation action on wetlands in Latin America.

Given that the challenges are growing rapidly and overwhelmingly, effective conservation action needs to occur as soon as possible.

Arctic and boreal wetland complexes of Alaska and Canada are likewise fairly pristine and compose the vast majority of remaining wetland acreage in North America. Over 160 million ha of arctic, subarctic, or boreal wetland exist. Waterbirds use these habitats differently in these landscapes, as suggested by the concentrations of breeding loons, Black Brant, Oldsquaws, White-winged Scoters, and King Eiders on wetlands characterized by dense stands of Arctophola fulva (Derksen et al. 1981). For several grazing species, such as Cackling Canada Geese, temporal changes in drying wetlands provide new foraging opportunities with the germination of food plants (Sedinger and Raveling 1986).

As human development expands in the arctic, proactive identification of critical waterbird habitats is essential to make viable land use decisions. Remote sensing techniques can provide habitat classifications for these vast landscapes (Markon and Derksen 1994; Kempka et al. 1994), and avian seasonal selection of habitat must be investigated across these wetland types (Derksen et al. 1981).

IV. CONCLUSIONS AND FUTURE DIRECTIONS

A. WETLAND SYSTEMS

For all wetland wildlife species achieving a "no net loss" status of wetlands is an essential first step to ensure that further deterioration of the nation's wetland base does not continue. This is especially critical in areas with the highest densities of both humans and waterbirds such as regions along the Atlantic, Gulf, Pacific, and Great Lakes coasts.

Protection of remaining large tracts of forested wetlands along major river systems throughout the country, but especially in the southeast are badly needed. These systems are crucial to protect the water quality and ecological integrity of riparian zones and estuaries into which they feed. Coastal breeding populations of White Ibises demonstrate the landscape connectedness of different types of wetlands by requiring freshwater inland feeding sites as well as brackish estuarine nesting sites (Bildstein 1993). As the floods of 1993 in the midwestern U.S. illustrate, the loss of forested wetlands and their absorptive capacities along the Mississippi and its

tributaries have proven to be costly both environmentally and in human lives and property.

Research needs to assess the quality of different types of restored and created wetlands to determine their long-term viability as functioning systems. Questions of contaminant levels, parasite levels, and quality of the prey in such wetlands warrant further research. Similarly, the relative value of impoundments for waterbirds needs to be addressed. Expanded efforts are needed to evaluate how water-level management in impoundments influences use by species of birds other than shorebirds, rails, waders, and waterfowl (Fredrickson and Taylor 1982; Fredrickson and Reid 1986).

The aquaculture industry has been expanding in the southern U.S. and many depredation permits have been issued to control a variety of fish-eating species. Research is needed to design these facilities to reduce their attractiveness to fish-eating birds, especially cormorants and wading birds. Restoring natural wetlands near aquaculture ponds is an alternative that needs investigation.

Reduction in irrigation drainwater contamination in the western U.S. needs to be addressed. The problems identified for wildlife at the Kesterson National Wildlife Refuge in California (Ohlendorf et al. 1986) may be echoed from a number of other locations in the arid regions of the west.

Human disturbance is a real and growing concern to wildlife managers. Studies are needed to identify which species are most vulnerable and how different types of disturbance (e.g., pedestrians, pets, heavy equipment) at different periods of the year influence waterbirds. More restricted access and enforcement are needed, especially in coastal waters where boating and other types of recreation are threatening many species of waterbirds and shorebirds (Bratton 1990). Island protection and zoning of refuges and parks needs to be more rigorous.

At landscape levels, geographers and biologists need to interact to develop models to predict how various types of wetland habitats will be influenced by potential increases in sea level, a phenomenon that may have a major influence on habitat use patterns in the future and can help guide decisions concerning public land use.

B. BIRD USE AND IMPACT OF WETLAND CHANGE

Systematically collected data on population dynamics of wetland-associated birds generally are unavailable, except for some species of waterfowl. Impacts on wetland changes will not be understood until regular and systematic monitoring of species and populations is conducted.

Basic studies on the niches and resource use of wetland birds is needed. The basic biology of some species is known, but few studies address long-term dynamics and ecological energetics of species such as warblers, that may use wetlands for only short periods each year. Nearly 800 species can be described as waterbirds and some 260 of these occur in North America (Reid 1993), yet a wide diversity of other avian groups (e.g., wood warblers, sparrows, woodpeckers) also use wetland resources.

Little is known about the fundamental assumptions of how birds use resources and respond to changes in wetlands in relation to size, distribution, juxtaposition, surrounding land use, and degree of fragmentation. Integrating landscape ecology principles into conservation strategies for wetland birds is crucial.

The distributions of most birds are non-random in relation to wetland distribution. Degradations dramatically alter resource availability and differently affect location, season, and type. Wetland types that are less permanently flooded are especially critical and yet are not well documented or protected for wetland birds.

Some bird species are highly concentrated in remaining wetland areas that supply key resources, especially foods and sanctuary. These concentrations increase the susceptibility of species and populations to parasites, disease, and environmental catastrophes. Efforts should be made to conserve key sites, but restoration of alternate sites and former distributions also must occur to achieve long-term stability of populations.

Many bird species use wetlands only during a specific period of the annual cycle, consequently the values of wetlands to some species are overlooked and the diversity of use and the complexity of food webs is underestimated.

Most birds that are obligate wetland species require, and use, resources in a variety of wetland types and typically require a complex of wetlands located within their range limits.

These seasonal and long-term dynamics of resources have influenced the basic behavioral, morphological, and physiological adaptations of species that allow them to efficiently use resources and survive difficult times.

Wetlands are extremely important for many threatened and endangered species. The causes for species crashes are often related to fundamental failures in wetland food webs, not to loss of individual wetland sites.

The excellent data bases on certain waterfowl species may be useful to predict effects of wetland change on other birds that use similar resources.

For most birds that are declining, conservation must seek "net gains" in wetland resources, not just protect the *status quo*. Increases in values will require restoration, enhancement, and active management. Conservation programs for wetland-associated birds must recognize the needs of other non-bird species and seek to emulate natural community and ecosystem dynamics and food webs. Management strategies, whether protection or active manipulations, must include considerations for all species and seek basic biological information to make informed

decisions. An integral part of these strategies must include conservation of surrounding terrestrial habitats that are important roosting habitats for many avian species.

C. CONSERVATION PROGRAMS

Public policy and government decision-making require accurate economic valuation of the public benefits of wetlands. Quantification within the guise of conventional market economics is the most straightforward at the local scale for harvestable products such as food and fuel. The recreation and aesthetic values of pristine wetland habitats and their diversity of plants, fish, and wildlife can also be estimated using conventional economic methods. Values can be estimated for businesses supported by recreational experiences, and estimates can be made based on willingness to pay for the recreational experience.

Higher level ecological values, however, are generally external to the market system, primarily because the benefits are accrued by society as a whole, not by the individual, bespeaking the tragedy of the commons. Early efforts to assign dollar values to these intangible benefits were difficult and less than

satisfying (Foster 1978), in part because of the extensive spatial and temporal variation in wetlands and in how the public values wetlands. Because wetland values cannot be described in terms of supply and demand forces, serious problems with methodology and assumptions arise. For example, willingness to pay bore little relation to the economic value of wetlands, because society never paid for ecological functions in the past. Some attempts have been made to assign economic value to these functions based on what it would cost to replace the function.

A developing body of economic theory, ecological economics, stresses that "the economic value of ecosystems is connected to their physical, chemical, and biological role in the long-term, global system - whether the present generation of humans fully recognizes that role or not" (Costanza et al. 1991). The economic and societal benefits of the higher level ecological functions are far-reaching, as are the implications of the loss of wetlands.

At the policy level, a common definition of wetlands should be delineated and adopted by federal and state agencies. The definition of wetlands embodied in the 1989 federal wetlands

delineation manual should continue to be the standard definition used. The National Academy of Sciences should perform a complete review of the various definitions used and reconcile any misunderstandings and differences (Environmental Defense Fund and World Wildlife Fund, 1992). Specific goals for wetlands protection and wetlands restoration are needed. The National Academy of Sciences has defined restoration goals for aquatic system in its recent report as follows: net restoration of 10 million acres of wetlands within 20 years (by 2010), restoration of 400,000 miles of rivers by 2010, and restoration of 1 million acres of lakes by 2000, with another 1 million acres over the long term. The National Academy of Sciences goals for restoration should be adopted on an interim basis until such time as additional scientific evidence can be compiled as the basis for new goals.

Support and improvement of existing wetlands protection programs should be continued. It is critical that Section 404 of the Clean Water Act not be weakened. Furthermore, watershed planning provisions being considered to reduce non-point sources of pollution should not be used as vehicles to weaken compliance

with water quality standards. In addition, the approach to watershed planning should include mechanisms to restore degraded wetlands and riparian habitats. Appropriations for the Wetlands Reserve Program and the Conservation Reserve Program should be expanded to help in achieving restoration goals through assistance to farmers.

New opportunities to restore critical water-dependent ecosystems and reform institutions responsible for managing public land and water supplies should be seized. The U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation have been given new mandates by Congress to focus more on resource management and less on construction of new projects. Furthermore, several specific pieces of legislation have been passed that create new mechanisms for these institutions to pursue ecosystem restoration in particular regions, including California's Central Valley, the Truckee-Carson River system in the Great Basin, the Florida Everglades, the Columbia River system in the Pacific Northwest, and coastal Louisiana.

The federal Coastal Wetlands Protection, Planning, and Restoration Act of 1990, for example, provides $35 million per

year for wetlands restoration activities, while the state of Louisiana established a Wetlands Conservation and Restoration Fund in 1989 with annual allocations between $15 and $25 million (Environmental Defense Fund and World Wildlife Funds 1992). Similarly, the Truckee-Carson Water Rights Settlement Act of 1990 created a water-rights acquisition fund to purchase water to restore the Stillwater Wildlife Refuge downstream of the Bureau of Reclamation's Newlands project. The Central Valley Project Improvement Act of 1992 also established a Restoration Fund with initial appropriations of $35 million for restoration programs whether physical improvements or water and land acquisitions. These examples provide a foundation on which to build effective protection and restoration programs on a broader basis.

New initiatives that foster private wetlands protection and restoration activities must be pursued. National goals for restoration must be translated into regional and local goals, whereby particular habitats and resources can be targeted for protection or enhancement. Once goals are established, flexible mechanisms -- including a combination of conservation easements, land and water donations, acquisitions, purchases, and exchanges,

tax incentives, direct subsidies for protection, compatible economic activities, and transferable development rights programs can be implemented at local and regional levels to provide a framework and a system of incentives for private protection and restoration activities.

Federal and state laws can be re-structured to support local guidance and control over implementation of restoration activities, such as the "restoration funds" discussed above of which some are jointly administered by government agencies and local organizations. Federal funds could be targeted for restoration projects in particular basins or regions to produce a more significant ecological benefit than the current wide scattering of Wetland Reserve Program funds. In conjunction with these efforts to promote directly wetlands protection and restoration, policies that encourage continued destruction of wetlands and other water-dependent ecosystems should be reformed. Federal fees for irrigation water, grazing allotments, mining claims, and timber concessions should be increased to discourage waste of limited natural resources and to better reflect the true value of the resources being consumed.

If any of these policies are to be successfully implemented, decision makers at all levels must understand the significant values and benefits provided by aquatic biodiversity and the wetland and riparian habitats on which they depend, as well as the substantial costs we will incur, both monetary and ecological, if we fail to protect or restore what few wetlands remain.

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Table 1. Wetland acreage for selected geographic regions in the conterminous United States.

Location	Estimated Wetland (Acres)[1]
Maine and Upper New England *	5.6 million
Chesapeake Bay States (MD, VA, DE) *	1.6 million
Coastal Plain of the Carolinas *	10.0 million
Florida	11.0 million
Bottomlands of Georgia and Alabama	8.0 million
Louisiana *	8.8 million
Texas *	7.6 million
Lower Mississippi Plain States (MO, AR, MS) *	7.3 million
Great Lakes States (MN, WI, MI) *	19.5 million
Prairie Pothole Region (ND, SD) *	4.1 million
Pacific Northwest (OR, WA) *	2.3 million
Subtotal	85.8 million
All other states in conterminous U.S.	17.2 million

Conterminous U.S. total	103 million

[1] Rounded estimates

* Denotes inclusion in North American Waterfowl Management Plan Joint Venture Areas.

Table 2: Ranking of states by projected increase in population: 1990-2010 (Source: World Resources Institute 1992).

	State	1990 Population	2010 population	Projected increase/ decrease
1	California	29,760,000	38,096,000	8,336,000
2	Florida	12,938,000	19,702,000	6,764,000
3	Georgia	6,478,000	9,378,000	2,900,000
4	North Carolina	6,629,000	8,735,000	2,106,000
5	Virginia	6,187,000	8,222,000	2,035,000
6	Arizona	3,665,000	5,537,000	1,872,000
7	Maryland	4,781,000	6,446,000	1,665,000
8	New Jersey	7,730,000	8,846,000	1,116,000
9	Texas	16,987,000	17,990,000	1,003,000
10	Tennessee	4,877,000	5,727,000	850,000
11	South Carolina	3,487,000	4,304,000	817,000
12	Missouri	5,117,000	5,665,000	548,000
13	New Hampshire	1,109,000	1,650,000	541,000
14	Hawaii	1,108,000	1,590,000	482,000
15	Alabama	4,041,000	4,469,000	428,000
16	Nevada	1,202,000	1,618,000	416,000
17	Massachusetts	6,016,000	6,431,000	415,000

18	New Mexico	1,515,000	1,922,000	407,000
19	Mississippi	2,573,000	2,858,000	285,000
20	Delaware	660,000	933,000	273,000
21	Minnesota	4,375,000	4,632,000	257,000
22	Connecticut	3,287,000	3,514,000	227,000
23	Arkansas	2,531,000	2,559,000	208,000
24	Maine	1,228,000	1,430,000	202,000
25	Pennsylvania	11,882,000	12,038,000	156,000
26	Utah	1,723,000	1,879,000	156,000
27	Illinois	11,431,000	11,571,000	140,000
28	New York	17,990,000	18,129,000	139,000
29	Alaska	550,000	669,000	119,000
30	Indiana	5,544,000	5,655,000	111,000
31	Rhode Island	1,003,000	1,105,000	102,000
32	Vermont	563,000	658,000	95,000
33	Colorado	3,294,000	3,385,000	91,000
34	Oregon	2,842,000	2,922,000	80,000
35	Kansas	2,478,000	2,488,000	10,000
36	South Dakota	696,000	704,000	8,000
37	Michigan	9,295,000	9,301,000	6,000

38	Idaho	1,007,000	985,000	-22,000
39	Ohio	10,847,000	10,803,000	-44,000
40	Wyoming	454,000	366,000	-88,000
41	Montana	799,000	692,000	-107,000
42	North Dakota	639,000	531,000	-108,000
43	Kentucky	3,685,000	3,562,000	-123,000
44	Nebraska	1,578,000	1,443,000	-135,000
45	Wisconsin	4,892,000	4,562,000	-240,000
46	West Virginia	1,793,000	1,482,000	-311,000
47	Louisiana	4,220,000	3,876,000	-344,000
48	Oklahoma	3,146,000	2,660,000	-486,000
49	Washington	4,867,000	4,369,000	-498,000
50	Iowa	2,777,000	2,251,000	-526,000

Table 3. Abundance indices for No. Am. Shorebirds.

Species	Abundance index in: pre-1875	Ca. 1910	Current
a. Temperate zone, beach-nesting species			
Snowy Plover	?	?	5
Wilson's Plover	2	4	4
Piping Plover	2	4	5
American Oystercatcher	2	5	3
b. Temperate zone wetland species			
American Avocet	2	5	2
Black-necked Stilt	3	5	3
Willet	1	4	2
Marbled Godwit	2	4	2
Wilson's Phalarope	?	?	2
c. Taiga/low Arctic			
Greater Yellowlegs	2	2	2
Lesser Yellowlegs	1	2	1
Spotted Sandpiper	2	2	2
Solitary Sandpiper	3	3	3
Wandering Tattler	?	?	3

Hudsonian Godwit	3	5	3
Least Sandpiper	2	3	2
Common Snipe	1	3	2
d. Low/Mid-Arctic			
Lesser Golden Plover	1	5	3
Semipalmated Plover	2	4	2
Eskimo Curlew	1	5	6
Whimbrel	3	3	3
Black Turnstone	?	?	3
Surfbird			3
Semipalmated Sandpiper	1	3	1
Western Sandpiper	?	?	2
Pectoral Sandpiper	1	2	1
Purple Sandpiper	1	4	3
Rock Sandpiper			3
Dunlin	1	2	2
Stilt Sandpiper	?	3	3
Short-billed Dowitcher	1	4	2
Long-billed Dowitcher	?	?	2
e. Middle/high Arctic			

Black-bellied Plover	2	4	2
Ruddy Turnstone	2	4	2
Red Knot	1	4	3
Sanderling	1	2	1
White-rumped Sandpiper	?	?	2

[a] Abundance indices range from 1 (abundant) to 6 (nearly extinct)

Table 4. Selected Events in Wetlands Management

1802 U.S. Army Corps of Engineers created for military and civilian construction works, including navigation.

1849 Swamp Lands Act passed to allow settlement of swamplands with agreement to clear land.

1862 Homestead Act passed to open up western lands to settlement and development.

1877 Desert Lands Act passed to open southwest for settlement.

1899 Rivers and Harbors Act gives USACE more power to modify rivers and floodplains for navigation.

1902 Reclamation Act passed giving authority to the U.S. Bureau of Reclamation to develop water supplies for land reclamation and irrigation.

1903 President Roosevelt designates the first national wildlife refuge at Pelican Island, Florida, as a bird sanctuary.

1936 Flood Control Act passed following an earlier version passed in 1927 giving the Army Corps authority for flood control efforts on major streams and appropriating funds for public flood control works.

1948 Water Pollution Act establishes study program and grants for waste treatment.

1950 Dingell-Johnson Act authorizes federal aid for restoration of freshwater fish.

1950 President's Water Resources Policy Commission.

1954 Watershed Protection and Flood Prevention Act establishes technical and financial aid to local organizations for watershed work plans.

1964 Wilderness Act authorizes reservation of federal lands as wilderness areas.

1968 Wild and Scenic Rivers Act authorizes reservation of river reaches for preservation.

1969 National Environmental Policy Act requires federal agencies to prepare environmental impact statements on projects with public participation and develop mitigation plans.

1972 Clean Water Act authorizes the Environmental Protection Agency to create and enforce water quality standards and guidelines for permitting draining and filling of wetlands (administered by the Army Corps).

1973 Endangered Species Act authorizes the Fish and Wildlife Service to list as threatened or endangered specific species, to designate critical habitat areas, and to develop recovery plans.

1977 Executive Order 11990 mandating that all federal agencies work to minimize impacts on wetlands.

1985 Food Security Act establishes the Wetlands Reserve Program administered by the U.S. Dept. of Agriculture's Soil Conservation Service to provide funds to farmers who keep wetlands out of production.

1986 Emergency Wetlands Resources Act.

1988 The National Wetlands Policy Forum sets a goal of "no net loss" of wetlands and Presidential candidate George Bush endorses the goal.

1990 Water Resources Development Act passed.

1990 Truckee-Carson Water Rights Settlement Act passed authorizing water-rights acquisitions from a Bureau of Reclamation project for the purposes of restoring the Stillwater National Wildlife Refuge wetlands.

1990 Coastal Wetlands Protection, Planning, and Restoration Act authorizes $35 million for wetlands restoration in coastal Louisiana.

1991 National debate erupts over Vice-President Quayle's attempt to change the definition of wetlands used in the 1989 federal wetlands delineation manual thereby potentially excluding from federal protection 50% of the nation's remaining wetlands.

1992 Central Valley Project Reform Act sets aside 800,000 acre-feet of water for fish and wildlife protection and establishes a Restoration Fund with an initial $35 million.