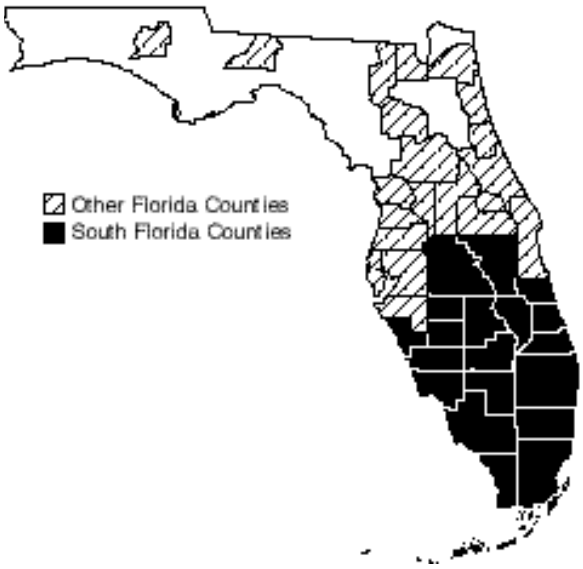
Wood Stork

Mycteria americana

Federal Status:	**Endangered (Feb. 28, 1984)**
Critical Habitat:	**None Designated**
Florida Status:	**Endangered**
Recovery Plan Status:	**Contribution (May 1999)**
Geographic Coverage:	**South Florida**

Figure 1. Florida distribution of the wood stork.



Wood storks (*Mycteria americana*) are one of two species of storks that breed in North America. This large, long-legged inhabitant of marshes, cypress swamps, and mangrove swamps reaches the northern limit of its breeding range in the southeastern U.S., where it breeds in colonies with great egrets, snowy egrets, white ibises, and many other species. The unique feeding method of the wood stork gives it specialized habitat requirements; the habitats on which wood storks depend have been disrupted by changes in the distribution, timing, and quantity of water flows in South Florida. The population declines that accompanied this disruption led to its listing as an endangered species and continue to threaten the recovery of this species in the U.S.

This account represents South Florida's contribution to the rangewide recovery plan for the wood stork (FWS 1997).

Description

The wood stork is a large, long-legged wading bird, with a body length (head to tail) of 85 to 115 cm and a wingspan of 150 to 165 cm. Their plumage is white, except for iridescent black primary and secondary feathers and a short black tail. On adult wood storks, the rough scaly skin of the head and neck is unfeathered and blackish in color. Their legs are dark with dull pink toes. The bill color is blackish. Male and female wood storks are similar in appearance, although male wood storks tend to be larger, have longer wingspans and weigh more.

Immature storks, up to the age of about 3 years, differ from adults in that their bills are yellowish or straw colored and they exhibit varying amounts of dusky feathering on the head and neck. During courtship and the early nesting season, adults have pale salmon coloring under the wings, fluffy undertail coverts that are longer than the tail, and toes that brighten to a vivid pink.

In the field, wood storks are distinctive among North American wading birds due to their long, heavy bills, black primary and secondary feathers, and black tails. Few other North American wading birds, except sandhill cranes (*Grus canadensis)*, whooping cranes (*Grus canadensis americana*), white ibises (*Eudocimus albus)*, and roseate spoonbills (*Ajaia ajaja)* fly with their necks and legs extended. Wood storks can be distinguished from sandhill cranes by their white plumage; they can be distinguished from whooping cranes by their size (the body of wood storks are 89 to115 cm while whooping cranes are 127 to151 cm), black secondary feathers, and black tail feathers. White ibises and wood storks both have black flight feathers on the wing tips. However, the wood stork is easily distinguished by its black head and its heavy bill. The roseate spoonbill is characteristically pinkish in color and has a spoonbill. At large distances, soaring white pelicans (*Pelecanus erythrorhynchos*) and storks appear similar; both soar in flocks at great heights and have similar color patterns.

Taxonomy

The wood stork is one of 17 species of true storks (Ciconiidae) in the world. The wood stork is one of three stork species found in the western hemisphere and is the only one that breeds north of Mexico (Ogden 1990). The wood stork has no described subspecies, races, or distinctive subpopulations (Palmer 1962).

Distribution

Breeding populations of the wood stork occur from northern Argentina, eastern Peru, and western Ecuador north to Central America, Mexico, Cuba, Hispaniola, and the U.S. (AOU 1983). In the U.S., wood storks historically nested in all coastal states between Texas and South Carolina (Wayne 1910, Bent 1926, Howell 1932, Oberholser 1938, Dusi and Dusi 1968, Cone and Hall

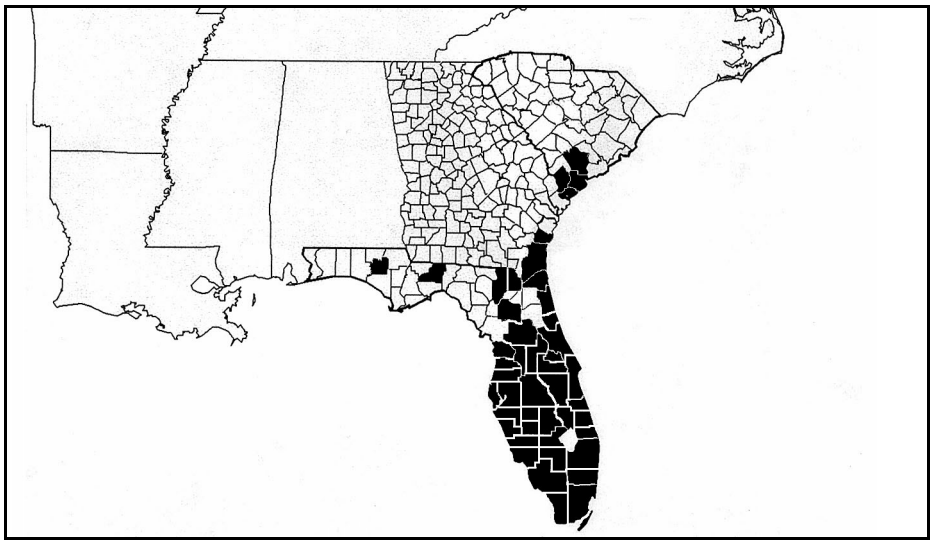


Figure 2. Breeding distribution of the wood stork in the United States (FWS 1996).

Wood stork.
Original photograph by Brian Toland.

1970, Oberholser and Kincaid 1974). Currently, wood storks breed in Florida, Georgia, and coastal South Carolina (Figures 1 and 2). Post breeding storks from Florida, Georgia, and South Carolina disperse occasionally as far north as North Carolina and as far west as Mississippi and Alabama.

In the U.S., the post breeding dispersal of the wood stork is extensive, with annual variation. The wood stork has been reported both as a casual and regular visitor, ranging from southern California and southern Arizona, north to northern California, southern Idaho, Montana, Colorado, Nebraska, southeastern South Dakota, Missouri, Illinois, southern Michigan, and southern Ontario, Canada; from the Gulf of Mexico north to Arkansas and western Tennessee; and along the Atlantic coast to Maine, southern New Brunswick, Canada, and New York, south to its breeding range in Florida, Georgia, and South Carolina. It is suspected that most wood storks sighted in Arkansas, Louisiana, Texas, and points farther west are birds that have dispersed from colonies in Mexico (FWS 1997). Some of the sightings in this region may also be wood storks dispersing from southeastern U.S. breeding colonies, but the amount of overlap or interchange between populations in the southeastern U.S. and Mexico is unknown.

In South Florida, breeding colonies of the wood stork occur in Broward, Charlotte, Collier, Miami-Dade, Hardee, Indian River, Lee, Monroe, Osceola, Palm Beach, Polk, St. Lucie, and Sarasota counties. Wood storks have also nested

in Martin County, and at one time or another, in every county in South Florida. It is believed that storks nesting in north Florida, Georgia, and South Carolina move south during the winter months (December through February). Bancroft *et al* (1992) have shown that the number of storks feeding in the three WCA's of the central and northern Everglades varied greatly among winters, ranging from a low of 1,233 birds in a high-water year to 7,874 birds in a low-water year. In most of the study years, 1985 to 1989, the total number of storks in the WCA's increased substantially between December and January, and dropped off sharply after March. In some years, the inland marshes of the Everglades have supported the majority (55 percent) of the U.S. population of wood storks (FWS 1997).

Habitat

The wood stork is primarily associated with freshwater and estuarine habitats for nesting, roosting, and foraging. Wood storks typically construct their nests in medium to tall trees that occur in stands located either in swamps or on islands surrounded by relatively broad expanses of open water (Palmer 1962, Rodgers *et al.* 1996, Ogden 1991). Historically, wood storks in South Florida established breeding colonies primarily in large stands of bald cypress (*Taxodium distichum*) and red mangrove (*Rhizophora mangle*). The large, historic Everglades NP nesting colonies were in estuarine zones. These estuarine zones are also an important feeding habitat for the nesting birds. In one study of wood stork nesting throughout Florida, which was conducted prior to the 1960s, more than half of all wood stork nests were located in large bald cypress stands, 13 percent were located in red mangrove, eight percent in partially harvested bald cypress stands, six percent in dead oaks (*Quercus* spp.), and five percent in small pond cypress (*T. distichum* var. *nutans*) (Palmer 1962). Wood storks have also been observed constructing their nests in custard (pond) apple (*Annona glabra*), black gum (*Nyssa biflora*), buttonwood (*Conocarpus erectus*), black mangrove (*Avicenna germinans*), strangler fig (*Ficus aurea*), and southern willow (*Salix carolina*). Coastal nest sites occur in red mangroves and, occasionally, Brazilian pepper (*Schinus terebinthifolius*), cactus (*Opuntia stricta*), and Australian pine (*Casuarina equisetifolia*).

During the nonbreeding season or while foraging, wood storks occur in a wide variety of wetland habitats. Typical foraging sites for the wood stork include freshwater marshes and stock ponds, shallow, seasonally flooded roadside or agricultural ditches, narrow tidal creeks or shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Because of their specialized feeding behavior, wood storks forage most effectively in shallow-water areas with highly concentrated prey (Ogden *et al.* 1978, Browder 1984, Coulter 1987). In South Florida, low, dry-season water levels are often necessary to concentrate fish to densities suitable for effective foraging by wood storks (Kahl 1964, Kushlan *et al.* 1975). As a result, wood storks will forage in many different shallow wetland depressions where fish become concentrated, either due to local reproduction by fishes, or as a consequence of seasonal drying.

The loss or degradation of wetlands in central and South Florida is one of the principal threats to the wood stork. Nearly half of the Everglades has been drained for agriculture and urban development (Davis and Ogden 1994). The Everglades

Agricultural Area (EAA) alone eliminated 802,900 ha of the original Everglades, and the urban areas in Miami-Dade, Broward and Palm Beach counties have contributed to the loss of spatial extent of wood stork habitat. Everglades NP has preserved only about one-fifth of the original extent of the Everglades, and areas of remaining marsh outside of the Everglades NP have been dissected into impoundments of varying depths.

The U.S. Army Corps of Engineers' (COE) Central and Southern Florida (C&SF) Project encompasses 4,660,000 ha from Orlando to Florida Bay and includes about 1,600 km each of canals and levees, 150 water control structures, and 16 major pump stations. This system has disrupted the volume, timing, and direction of fresh water flowing through the Everglades. The natural sheet flow pattern under which the Everglades evolved since about 5,000 years ago has not existed for about 75 years (Leach *et al*. 1972, Klein *et al.* 1974). The diversion of natural sheet flow to canals, the loss of fresh water to seepage and to pumping to tidal waters, and the extraction of fresh water for irrigation and urban water supply has led to saltwater intrusion in coastal counties from St. Lucie County on the east coast to Sarasota County on the west coast.

Although the major drainage works completed the conversion of wetlands to agriculture in the EAA by about 1963, loss of wetlands continues to the present at a slower, but significant rate. In the entire State of Florida between the mid-1970s to the mid-1980s, 105,000 ha of wetlands (including marine and estuarine offshore habitats) were lost; we do not have an estimate for freshwater wetlands in central and south Florida (Hefner *et al.* 1994).

Behavior

Courtship

Mating occurs after a period of highly ritualized courtship displays at the nest site (Kahl 1972). As a female bird approaches, male birds establish themselves at potential nest sites and perform ritualized preening behavior. Rival males will extend their necks, grab their opponents' bills, and clatter their bills loudly a few times. Females respond by bill gaping and a spread-winged balancing posture. Females will be turned away initially, but after repeated approaches, will respond by swaying their heads, preening, or playing with nearby twigs (Kahl 1972). During copulation, males loudly clatter their bills. Mated pairs greet each other with exaggerated, mutual up-down head movements and hissing calls.

Reproduction

Wood storks tend to use the same colony sites over many years, as long as the sites remain undisturbed and sufficient feeding habitat remains in the surrounding wetlands. Site turnover rates for the colonies in South Carolina are very low at 0.17 colonies per year. Current year colonies have an 89 percent likelihood of remaining active in consecutive years. However, many of these South Carolina colonies are relatively recent.

Traditional wetland nesting sites may be abandoned by storks once local or regional drainage schemes remove surface water from beneath the colony trees. Maintaining adequate water levels to protect nests from predation is a critical

factor affecting production of a colony. The lowered water levels allow nest access by raccoons and other land-based predators. As a result of such drainages and predation, many storks have shifted colony sites from natural to managed or impounded wetlands. The percentage of wood storks that nested in either altered wetlands (former natural wetlands with impounded water levels) or artificial wetlands (former upland sites with impounded water) in central and north Florida colonies increased from about 10 percent in 1960 to between 60 and 82 percent between 1976 and 1986.

Wood storks are seasonally monogamous, probably forming a new pair bond every season. Three and 4-year-old birds have been documented to breed, but the average age of first breeding is unknown. Once wood storks reach sexual maturity they are assumed to nest every year; there are no data on whether they breed for the remainder of their life or whether the interval between breeding attempts changes as they age (FWS 1997).

Wood storks construct their nests in trees that are usually standing in water or in trees that are on dry land if the land is a small island surrounded by water. The nest are large rigid structures usually found in the forks of large branches or limbs. Storks may add guano to the nest to stabilize the twigs. (Rodgers *et al*. 1988). The nest may be constructed in branches that are only a meter above the water or in the tops of tall trees. They construct their nests out of sticks, with a lining of finer material. Their nests are flat platforms, up to 1 m in diameter, and are maintained by the adult storks throughout the breeding season. Although both adults maintain the nest, the male wood stork usually brings nest material to the female after they complete their courtship (Palmer 1962).

The date on which wood storks begin nesting varies geographically. In Florida, wood storks lay eggs as early as October and as late as June (Rodgers 1990). In general, earlier nesting occurs in the southern portion of the state (below 27°N). Storks nesting in the Everglades and Big Cypress basins, under pre-drainage conditions (1930s to 1940s), formed colonies between November and January (December in most years) regardless of annual rainfall and water level conditions (Ogden 1994 and 1998). In response to deteriorating habitat conditions in South Florida, wood storks in these two regions have delayed the initiation of nesting, approximately two months, to February or March in most years since the 1970s. This shift in the timing of nesting is believed to be responsible for the increased frequencies of nest failures and colony abandonment in these regions over the last 20 years; colonies that start after January in South Florida risk having young in the nests when May-June rains flood marshes and disperse fish.

Female wood storks lay a single clutch of eggs per breeding season. However, they will lay a second clutch if their nests fail early in the breeding season (M. Coulter 1996). Wood storks lay two to five (usually three) eggs depending on environmental conditions; presumably larger clutch size in some years are responses to favorable water levels and food resources. Once an egg has been laid in a nest, one member of the breeding pair never leaves the nest unguarded. Both parents are responsible for incubation and foraging (Palmer 1962). Incubation takes approximately 28 days, and begins after the first one or two eggs are laid; therefore egg-hatching is asynchronous.

Younger, smaller chicks are often the first to die during times of food stress (FWS 1997). It takes about 9 weeks for the young to fledge; once they fledge, the

young stay at the nest for an additional 3 to 4 weeks to be fed by their parents. Parents feed the young nestlings by regurgitating whole fish into the bottom of the nest; parents feed the young three to 10 or more times per day. Larger nestlings are fed directly bill to bill. Feedings tend to be more frequent when young are small. Ogden *et al.* (1978) reported that only one to two feedings per day, per nest, have been recorded in South Florida colonies when adults were forced to fly great distances to locate prey. Kahl (1964) calculated that an average wood stork family (two adults and two nestlings) requires 201 kg (443 lbs) of fish during a breeding season, and that a colony of 6,000 nests therefore requires 1,206,000 kg of fish during the breeding season. A similar calculation for a typical Everglades NP or Corkscrew Swamp colony with 200 nests would require 40, 200 kg (88,600 lbs) of fish during the breeding season.

The production of wood stork colonies varies considerably between years and locations, apparently in response to differences in food availability; colonies that are limited by food resources may fledge an average of 0.5 to 1.0 young per active nest; colonies that are not limited by food resources may fledge between 2.0 and 3.0 young per active nest (Ogden 1996a).

Foraging

Wood storks use a specialized feeding behavior called tactolocation, or grope feeding. A foraging wood stork wades through the water with its beak immersed and partially open (7 to 8 cm). When it touches a prey item, a wood stork snaps its mandibles shut, raises its head, and swallows what it has caught (Kahl 1964). Regularly, storks will stir the water with their feet, a behavior which appears to startle hiding prey (Rand 1956, Kahl 1964, Kushlan 1979). Tactolocation allows storks to feed at night and use water that is turbid or densely vegetated. However, the prey must be concentrated in relatively high densities for wood storks to forage effectively. The natural hydrologic regime in South Florida involves seasonal flooding of extensive areas of the flat, low-lying peninsula, followed by drying events which confine water to ponds and sloughs. Fish populations reach high numbers during the wet season, but become concentrated into smaller areas as drying occurs. Consumers, such as the wood stork, are able to exploit high concentrations of fish in drying pools and sloughs. In the pre-drainage Everglades, the dry season of South Florida provided wood storks with ideal foraging conditions by concentrating prey species in gator holes and other drainages in the Everglades basin. In coastal areas, the tidal cycle strongly influences use of saltwater habitats by wood storks. The relatively great tidal amplitudes characteristic of coastal marshes in northeast Florida, Georgia, and South Carolina serve to concentrate prey. similarly to the seasonal drawdowns found in freshwater systems (FWS 1997).

Storks forage in a wide variety of shallow wetlands, wherever prey reach high enough densities, and in water that is shallow and open enough for the birds to be successful in their hunting efforts (Ogden *et al.* 1978, Browder 1984, Coulter 1987). Good feeding conditions usually occur in relatively calm water, where depths are between 10 and 25 cm, and where the water column is uncluttered by dense patches of aquatic vegetation (Coulter and Bryan 1993). In South Florida, dropping water levels are often necessary to concentrate fish

to suitable densities (Kahl 1964, Kushlan *et al.* 1975). In east-central Georgia, where stork prey is almost twice as large as the prey in Florida, wood storks feed where prey densities are significantly lower than foraging sites in Florida (Coulter 1992, Coulter and Bryan 1993, Depkin *et al.* 1992). Typical foraging sites throughout the wood stork's range include freshwater marshes and stock ponds, shallow, seasonally flooded roadside or agricultural ditches, narrow tidal creeks or shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Almost any shallow wetland depression that concentrates fish, either through local reproduction or the consequences of area drying, may be used as feeding habitat.

Wood storks feed almost entirely on fish between 2 and 25 cm in length (Kahl 1964, Ogden *et al.* 1976, Coulter 1987). In South Florida, Ogden *et al.* (1976) found that certain fish species were taken preferentially. Mosquito fish (*Gambusia affinis*) were under represented in the diet in proportion to abundance, whereas, flagfish (*Jordanella floridae)*, sailfin mollies (*Poecilia latipinna)*, marsh killifish (*Fundulus confluentus*), yellow bullheads (*Ictalurus natalis)*, and sunfish (*Centrarchidae*) were over represented. Wood storks also occasionally consume crustaceans, amphibians, reptiles, mammals, birds, and arthropods. Fish densities at stork foraging sites varied from 15.6 individuals/m^2 in east-central Georgia to 40 individuals/m^2 in South Florida (Ogden *et al.*1978, Depkin *et al.* 1992).

Because wood storks rely on concentrated food sources which are patchily distributed over large areas, they need to be able to find new feeding grounds with minimal energy expenditure. Wood storks have soaring abilities that allow them to reach high altitudes and many kilometers without the energy expenditure of wing-flapping. A recent study suggested that soaring flight by storks can be accomplished at one-tenth the energetic cost of flapping flight (Bryan and Coulter 1995). The long distances they travel, however, shortens the time available to wood storks for feeding and reduces the number of times an adult stork can return to its nest to feed young (Kahl 1964). During the breeding season, feeding areas proximal to wood stork breeding colonies may play an important role in chick survival and provide enhanced opportunities for newly fledged birds to learn effective feeding skills.

Movements

During the non-breeding season (the summer to fall rainy season in South Florida), juvenile wood storks from South Florida colonies have been located throughout the Florida peninsula, southern Georgia, coastal South Carolina, central Alabama, and east-central Mississippi (Ogden 1996a). Additionally, marked individuals from a colony in east-central Georgia were found in the central Everglades during the winter. This information suggests that the southeastern population of wood storks is a single population that responds to changing environmental conditions through temporal relocation. Rodgers' (1996) data analysis of genetic variation in wood stork populations in South Florida, central Florida, north Florida, Georgia, and South Carolina support this evaluation.

Relationship to Other Species

Although the majority of nesting by the southeastern wood stork population no longer occurs in South Florida, the wetlands of the Everglades remain as important feeding areas for large numbers of storks during the dry season (winter-spring) (Bancroft *et al.* 1992). Wood storks may nest with many other wading bird species including white ibis (*Eudocimus albus*), tricolored herons (*Hydranassa tricolor*), snowy egrets *(Egretta thula)*, great egrets (*Casmerodius albus*), great blue herons (*Ardea herodias*), little blue herons (*Egretta caerulea*), and cattle egrets (*Bubulcus ibis*).

Suitable foraging habitat for the wood stork occurs in a specific band of the hydrologic and vegetative gradient of South Florida's landscape (see preceding discussions on foraging habitat and foraging behavior). Wood storks share that landscape with other species that occupy different (adjacent) positions along the same hydrologic and vegetative gradients. The endangered snail kite *(Rostrhamus sociabilis plumbeus)* is a nomadic species which moves throughout the South Florida landscape in response to changing habitat conditions. Optimal foraging conditions for the snail kite include areas of variable water depth that support apple snails. Conditions that provide good foraging habitat for the snail kite are too deep to provide optimal foraging conditions for the wood stork. The Cape Sable seaside sparrow (Ammodramus maritimus mirabilis) is another endangered species that utilizes the South Florida landscape and whose breeding success is dependent on hydrologic conditions that differ from those of the wood stork and the snail kite. The Cape Sable seaside sparrow requires short-hydroperiod dry marl prairie communities that are dominated by muhly grass (Muhlenbergia filipes) for their nesting cycle.

Historically, the large spatial extent and diverse environmental conditions of the South Florida landscape provided the different habitat requirements of these species (Davis and Ogden 1994). In the past century, draining and clearing activities dramatically reduced the spatial extent of the South Florida Everglades. At the same time, humans began to control the timing, distribution, and volumes of water in the South Florida landscape. These practices have resulted in a reduced diversity of environmental conditions and a resultant loss of heterogeneity in the South Florida landscape. The combination of reduced spatial extent and reduced landscape diversity now causes the environmental needs of these species to "conflict" in the current, less-diverse, managed landscape.

Status and Trends

The wood stork appears to be experiencing human population pressure throughout its entire New World range. Although specific information on the status and trends of breeding colonies is not available throughout its range, information that has been collected on specific colonies suggests that breeding and foraging habitats of the wood stork are declining in area and quality. Mexico listed its breeding population of the wood stork as endangered in 1991 because of dramatic population declines. The size of the most important breeding colonies for the wood stork in Mexico, which are located in the Usumacinta and Grijalva River Deltas in the states of Tabasco and Campeche, had

declined from 10,000 to 15,000 pairs in 1979 (Luthin 1987) to 3,000 to 3,500 pairs by 1990. Ogden *et al.* (1988) report 6,000-8,000 pairs as the range from 1971 to 1979. The wood stork is considered an endangered species in Belize where all colonies that were identified in the 1970s had disappeared by the late 1980s (Luthin 1987). Only one stable breeding colony is known to exist in Costa Rica; elsewhere in Central America, its status is unknown. Wood storks in South America face similar threats; in Cienaga de Zapatosa (Colombia), wood storks are threatened by pollution in the Rio Magdalena; in the Santa Rosa wetlands of Machalilla NP (Ecuador), wood storks may be affected by the construction of an oil terminal. The enormous wood stork rookeries in the Pantanal (primarily in Brazil), which is the world's largest wetland, are threatened by expanding agriculture, water pollution, and a massive project to drain, dike, and channelize this massive wetland ecosystem (Alho *et al.* 1988).

The U.S. population of the wood stork was listed as endangered in 1984 because it had declined by more than 75 percent since the 1930s (49 FR 7335). At the time, the FWS believed that the U.S. breeding population would be extirpated by the turn of the century if it continued to decline at the same rate. The original listing recognized the relationship between the declining wood stork population, the loss of suitable foraging habitat, and colony nesting failures, particularly in the breeding colonies in South Florida where human actions have reduced wetland areas by about 35 percent (Ogden and Nesbitt 1979).

Table 1. Wood stork breeding population in the southeast U.S., 1991-1995 (1997 wood stork recovery plan).

Year	Number of nests in southeast U.S.	Number of nests in South Carolina	Number of nests in Georgia	Number of nests in Florida	Number of nests in South Florida Ecoregion
1991	3,933	664	942	2,327	1,339
1992*	4,084	475	1091	2,518	2,518
1993	7,278	806	1649	4,823	2,546
1994	5,768	712	1468	3,588	2,015
1995	7,853	829	1501	5,523	2,639

* No data available for central or north Florida

We are uncertain about the size of the U.S. breeding population of wood storks before the statewide surveys of the late 1950s. Published and unpublished estimates of the size of the U.S. breeding population of wood storks prior to the statewide surveys are contradictory. For example, Allen (in Palmer 1962) wrote that the number of breeding wood storks in Florida exceeded 150,000 individuals during the 1930s. However, Ogden *et al.* (1978) believed this number was an overestimate resulting from an inflated estimate of the Lane River colony. Ogden (1978, 1996a) concluded that the wood stork population in the 1930s was probably less than 100,000 individuals, or between 15,000 and 25,000 pairs. More recent survey data provided by FWS (1997) in the wood stork recovery plan give a U.S. breeding population of 4,073 nests in 1991, 4,084 nests in 1992, 6,729 nests in 1993, 5,768 nests in 1994, and 7,853 nests in 1995 (Table 1). These data suggest that the breeding population of wood storks is increasing although the number of nests per year varies considerably. The next regionwide census of the wood stork population is scheduled for completion in 1999.

Since the 1960s, the wood stork population has shown a substantial decline in southern Florida and a substantial increase in northern Florida, Georgia, and South Carolina (Ogden et al. 1987). The number of pairs nesting in the traditional colony sites located in the Everglades and Big Cypress regions of southern Florida

Table 2. Pairs of nesting wood storks in Florida, 1991-1995 (from FWS 1997 wood stork recovery plan).

Colony Name	GFC Number	County	1991	1992	1993	1994	1995
Micanopy River Styx	605011	Alachua	40		55	175	250
Moore Creek	612007	Brevard					
U.S. 192 East & West	612138	Brevard	12		60		75
Grant Farm	616004	Brevard	60		150	100	
Micco North & South	616102	Brevard					48
Valkaria	616119	Brevard					25
SW Lake Washington	No Number	Brevard	60		185	105	300
Bluebill		Brevard	4				
Hall Island		Brevard	1				
	612127	Brevard			110	140	275
Lake Mary Jane	612037	Orange			100	105	175
Subtotal - Central Florida East Coast			**177**	**0**	**660**	**625**	**1,148**
Croom	611015	Hernando					175
Weeki Wachee		Hernando			12	16	
Hillsboro River	611163	Hillsborough				8	115
Lake Yale	612027	Lake	40		275	90	65
Ayers Point		Manatee			140		33
Devils' Creek	611021	Pasco			120	160	210
Little Gator Creek	611024	Pasco			60	9	200
Subtotal - Central Florida West Coast			**40**	**0**	**607**	**283**	**798**
Oleno	605103	Columbia	42				
Falling Creek		Columbia	80		150	110	110
Dee Dot	594004	Duval	250		260	300	325
Cedar Point	594105	Duval	9		85	30	120
Nassauvillo	594103	Nassau	5				
	606109	St. Johns			170		60
Subtotal - North Central Florida			**386**	**0**	**665**	**440**	**615**
Ochlocknee River	592003	Leon	160		115	95	144
Chaires	592001	Leon	225		230	130	179
Subtotal - North Florida			**385**	**0**	**345**	**225**	**323**
El Clair Ranch	616016	Hardee	400		320	240	415
Reedy Creek	612048	Polk			230	230	190
Lake Rosalie	616037	Polk	20		80	50	115
Mulberry NE	616114	Polk			75	130	110
	28048122	Polk			230	210	
Subtotal - SFER Central Florida			**420**	**0**	**935**	**860**	**830**
Pelican Island	616007	Indian River	110		225	110	230
Sewel Point	616025	Martin					65
Wescott Grove	616108	St. Lucie	40		25		8
Cypress Creek	616047A	St. Lucie	150		375	265	10
Subtotal - Central Florida East Coast			**300**	**0**	**625**	**375**	**313**
Tamiami Trail East	620122	Dade		130			
Cuthbert Lake	620139	Dade	150	275			
L-28 Crossover		Dade		158			
Tamiami Trail West		Dade		123			
East River		Dade			15		
Rookery Branch		Monroe		9			
Rodgers River Bay		Monroe		22		50	
Lane River		Monroe		1			
Paurotis Pond		Monroe			25	110	105
Loxahatchee 1&2	619139	Palm Beach	34				
SWA Catchment	No Number	Palm Beach					27
Corkscrew	619018	Collier	300	1800	426	450	864
Subtotal - Everglades and Big Cypress			**484**	**2,518**	**466**	**610**	**996**
Morgantown	616165	Charlotte	60				
North Port Charlotte	615040	Sarasota	75		520	170	500
Subtotal - Central Florida West Coast			**135**	**0**	**520**	**170**	**500**
Florida Population			**2,327**	**2,518**	**4,823**	**3,588**	**5,523**
North Florida			**988**	**0**	**2,277**	**1,573**	**2,884**
South Florida			**1,339**	**2,518**	**2,546**	**2,015**	**2,639**

declined from 8,500 pairs in 1961 to fewer than 500 pairs from 1987 through 1995. During the same years, the number nesting in Georgia increased from 4 pairs in 1965 to 1,501 pairs in 1995, and the number nesting in South Carolina increased from 11 pairs in 1981 to 829 pairs in 1995.

Between 1957 and 1960, the Florida and National Audubon Societies conducted a series of statewide aerial wood stork surveys of all known or suspected stork nesting colonies. In 1974, Florida statewide aerial surveys were initiated and repeated, annually, until 1986 (Ogden and Nesbitt 1979, Ogden and Patty 1981). In 1959, 14 breeding colonies in Florida supported an estimated 7,657 pairs of wood storks ; in 1960, 15 breeding colonies supported 10,060 breeding pairs; in 1975, 15 breeding colonies supported 5,382 breeding pairs; and in 1976, 17 breeding colonies supported 5,110 breeding pairs. More recent data provided in the wood stork recovery plan (FWS 1997) give a Florida breeding population of 2,327 pairs in 1991, 4,823 pairs in 1993, 3,588 pairs in 1994, and 5,523 breeding pairs in 1995. Twenty-one breeding colonies were present in 1991, 28 breeding colonies were present in 1993, 26 in 1994, and 30 in 1995. Data collections in 1992 did not include north and central Florida populations and are not included for comparisons.

The South Florida Ecosystem's contribution to the Florida population of wood storks is presented in Table 1. On the average the South Florida subpopulation represents 53 percent of the Florida population and 34 percent of the southeastern U.S. population. These data show a nesting population of 1,339 nests in 1991, 2,546 nests in 1993, 2,015 nests in 1994, and 2,639 nests in 1995.

The historical data and the recovery goals in the wood stork recovery plan reference the South Florida population as the Big Cypress Basin system and the Everglades Basin system. These two basins account for, on the average, between 30 to 37 percent of the South Florida Ecosystem sub-population. Table 2 provides a breakdown of the wood stork colonies listed in the recovery plan by general basin boundaries. Based on this general categorization of the colonies, four South Florida Ecosystem colony groupings are identified. These are the Central Florida East Coast colonies, the Everglades and Big Cypress (ECB) basin colonies, the Central Florida West Coast colonies, and the Central Florida colonies.

Historical data on colony locations identify the Everglades basin colonies and the Corkscrew colonies as the primary nesting locations for wood storks in South Florida (Ogden and Nesbitt 1979). In the late 1950s and early 1960s, wood storks nesting in the Everglades basin accounted for 12 percent [1,000 out of 8,609 nests (two-year average)] of the Florida population. The 1991 to 1995 survey data reveal that the Everglades basin colonies represents on the average, 3 percent [129 out of 4,065 nests (four-year average)] of the Florida population. In the late 1950s and early 1960s data, the Corkscrew colonies accounted for 51 percent [4,350 out of 8,609 nests (two-year average)]. The survey data also show that the Corkscrew colonies represent on the average, 12 percent [510 out of 4,065 nests (four-year average)] of the Florida population. More recent data provided by Ogden (1998) on three-year averages on nesting pairs of wood storks in the Everglades Basin (Loxahatchee NWR, WCAs 2 and 3, and mainland Everglades NP) show 343 pairs for the 1994 to 1996 average, 283 pairs for the 1995 to 1997 average, and 228 pairs for the 1996 to 1998 average. These averages are higher than the three-year average for the base years, 1986 to 1995. The base year averages were a low of 130 pairs and a high of 294 pairs. In the 1998 nesting year, only 25 pairs of wood storks were recorded nesting in ENP.

Rodgers *et al.* (1995) pointed out shortcomings in the aerial surveys used to generate population estimates for storks in Florida, Georgia, and South Carolina. Rodger's study compared ground surveys of wood stork colonies with aerial surveys of the same colonies. The variability of the aerial estimates was very large. For example, an approximately 95 percent confidence interval for the 1993 Florida statewide nesting population was 3,807 to 12,653 nests. The aerial count was 4,262 nests. The greatest variability occurred in large colonies with a high proportion of other white-plumage nesting birds. The FWS acknowledges the limitations involved in relying on aerial surveys for developing population estimates. However, over the long-term, aerial surveys are the most cost-effective method for estimating population trends. Ground surveys, while providing greater individual colony accuracy, are more time consuming and expensive on a regionwide basis. Rodgers recommended the incorporation of ground counts at selected colonies, training observers in presurvey flights, and replicating counts for each colony as actions to minimize variability in aerial surveys.

Historically, wood storks were recorded nesting in all coastal states between Texas and South Carolina (Ogden et al. 1987, FWS 1997); however, the largest colonies were located in South Florida. Since the 1960s, the decline in the U.S. population size of wood storks has been accompanied by a change in the size and distribution of their breeding colonies. Since the 1970s, the number of wood storks breeding in South Florida has substantially decreased. In north Florida, Georgia, and South Carolina the number of breeding wood storks has significantly increased (Ogden et al. 1987). From 1958 to 1960, 80 to 88 percent of wood stork nesting pairs were located at six sites in South Florida. Surveys from 1976 showed a decline to 68 percent, with a further decline to 13 percent in 1986. Since the late 1970s, a majority of wood storks have nested in central and north Florida, and an increasing number have nested in coastal colonies in Georgia and South Carolina. Between 1965 and 1995, the number of wood storks nesting in Georgia increased from four pairs to 1,501 pairs; between 1981 and

1995, the number of wood storks nesting in South Carolina increased from 11 pairs to 829 pairs. Since the 1970s, associated with this shift to the north, the U.S. southeast wood stork population appears to be gradually increasing, from a low of 3,000 to 4,000 pairs in the late 1970s, to over 7,800 pairs in the mid-1990s.

From 1991 through 1995, the FWS coordinated a systematic multi-state survey of wood stork nesting colonies. The results of these surveys suggest that, on average, from 1991 to 1995, approximately 35 percent of the total nesting effort in the southeast U.S. occurred in South Florida (Table 1). Historically, South Florida supported greater than 70 percent of the total nesting effort in the southeast U.S.; if these data are indicative of the ability of degraded South Florida ecosystems to support wood stork nesting, then South Florida ecosystems are functioning at approximately 50 percent of their previous capabilities.

Both 1992 and 1995 were years with high nesting effort. In 1995, nesting effort in South Florida improved from the previous two years, most likely in response to improved foraging conditions as a result of a rapid dry-down following the high-water years. In Everglades NP, Big Cypress National Preserve, Corkscrew National Sanctuary, and Florida Panther NWR, there were a total of approximately 996 nesting pairs. The North Port Charlotte nesting colony, which is north of the Corkscrew National Sanctuary had a breeding population of 500 nest pairs.

Since the 1970s, wood storks have also shifted their nest sites to areas that are artificial impoundments or where islands have been created by dredging activities (Ogden 1991). The percentage of nests in artificial habitats in central and north Florida has increased from approximately 10 percent of all nesting pairs in 1959 to 1960 to 60 to 82 percent between 1976 and 1986 (Ogden 1991). Nests in these artificially impounded sites often support exotic species such as Brazilian pepper (*Schinus terebinthifolius*) or Australian Pine *(Casuarina spp.*). Ogden (1996a) has suggested that the use of these artificial wetlands indicates that wood storks are not finding suitable conditions within natural nesting habitat or that they are finding better conditions at the artificial wetlands.

The 1960s and 1970s were a period of transition for wood storks breeding in South Florida. The most significant change was a delay in the timing of colony formation, from November and December in most years prior to the 1970s, to a pattern of colony formation between January and March. During the late 1970s, delayed colony formation by wood storks became the norm (Ogden 1994). Historically, wood storks formed colonies in November and December and concentrated the majority of their feeding efforts within the estuaries at the time of traditional colony formation (J. Ogden, SFWMD, personal communication 1996b).

The November/December feeding efforts appear to historically correspond to the annual mullet runs that occur on both of Florida's coastal systems. Before spawning, which usually peaks from November through January, large schools and concentrations of mullet form in the estuarine habitat (J. Cato, et al. 1976). During low tide, these large schools of mullet, which are concentrated in the shallow estuarine bays and mud flats, provide a concentrated food source for the wood stork during the early nesting cycle.

By the time the young of the year were ready to fledge and begin foraging independently, the dry season in South Florida was well underway and fish were

being concentrated in the interior freshwater sloughs, making feeding easy. Presently, wood storks in South Florida appear to be initiating nesting in response to the drying of the interior marshes in February to April; by the time the young fledge and begin foraging on their own, the wet season is underway, water levels in the interior marshes are rising, and many young starve. Such a change suggests that the estuarine habitats no longer provide suitable foraging conditions during the early dry season months, November to January.

The reproductive success of storks requires habitats that provide high concentrations of certain size-classes of fish, over a 125 to 150 day breeding cycle. Because seasonal and annual rainfall patterns are so variable in South Florida, the quantity of these foraging habitats also varies among years (J. Ogden, SFWMD, personal communication 1998). As a result, wood storks probably have always had highly variable reproductive success throughout their history, a phenomenon that is mitigated by the relatively long life spans of adult storks. Nevertheless, most authors agree that the decline of the U.S. wood stork population far exceeds the range of historic variability in total population size, and is correlated with water management activities in South Florida (Palmer 1962, Frederick 1993, Ogden 1996). During wet years, current water management practices prevent the formation of shallow pools that concentrate the fish on which wood stork forage. During dry years, current water management practices overdrain the freshwater sloughs, reduce freshwater flows into the mainland estuaries and reduce their ability to produce the fish on which wood storks forage.

As a result of these water management practices, wood storks in South Florida have experienced increased frequencies of nest failure. For example, in 1962, 1978, and 1983, wood storks in Everglades NP did not initiate nesting. In 1990, all nestlings in the Cuthbert Lake colony starved. In 1995, none of 250 nestlings survived in the Paurotis Pond colony. In the 1998 nesting year, only 25 pairs of wood storks were recorded nesting in ENP.

The threat of mercury contamination in the Everglades food web and its impact on the success of wood storks in South Florida is not clearly understood. Researchers have suggested that declines in wading bird populations may be partially a result of mercury toxicity (Frederick and Spalding 1994, Sundlof *et al.* 1994). In 1991, mercury contamination was documented in a wood stork carcass found in the Big Cypress basin (Facemire and Chlebowski 1991). The average mercury contents in the liver and feathers of the wood stork were 10.1 and 9.93 mg mercury per kg weight, respectively. The report concluded that, although the documented levels were generally less than those noted in the literature for fish-eating birds from mercury-contaminated freshwater systems, they were, most likely, sufficient to cause an adverse effect to the population. More recently, Beyer *et al.* (1997) found mercury concentrations in the livers of four wood storks collected in South Florida that were higher than the concentrations reported in seven other species of wading birds from South Florida. Frederick and Spalding (1994) reviewed the current knowledge on mercury contamination in wading birds, and concluded:

> In light of work that has been done in other species, it is not unreasonable to assume that high concentrations of mercury found recently in Everglades wading birds could result in the sublethal effects of reduced foraging and courtship ability. Each of these

> symptoms could result in reduced breeding effort and success and could be a powerful factor in explaining the reduced reproduction observed in the Everglades. The current state of knowledge on the effects of specific concentrations of mercury on wading bird behavior and survival is nonexistent.

Clearly much more specific research needs to be conducted on the levels of mercury in wood storks in the Everglades and the effects of these levels on the population. Potential impacts from contaminants need to be reconsidered in light of recent findings concerning the amount of mercury present in the Everglades ecosystem and the discovery of severe impacts of DDT/DDE-based estrogen-mimicking compounds on wildlife in a large Florida wetland (Guillette *et al*. 1994). The Science Sub-Group of the Interagency Task Force on the South Florida Ecosystem has acknowledged this in the section of their report dealing with threatened and endangered species. For the wood stork, the report calls for "a detailed study of the effects of mercury, other toxins, and parasites on the survivorship and reproductive success of wood storks" (Science Sub-Group, 1996).

Prognosis of the U.S. wood stork population between 1996 and 2020 is partially dependent on the success of the overall South Florida Ecosystem restoration effort. The freshwater flows need to be restored to more closely mimic the pre-drainage system; it is believed that by restoring the quantity, quality, timing, and distribution of flows in the remaining Everglades wetlands that the prey base so critical to wood storks during the breeding season will be recovered in both the estuarine and freshwater systems. Although we have lost approximately 35 percent of the original foraging grounds and the quality of much of the remaining wetlands has become degraded as foraging habitats, if our efforts to restore the South Florida Ecosystem are successful, we will re-create a system with heterogeneity and inherent variability, which should provide the prey base necessary to restore the wood stork in South Florida.

Management

South Florida has been severely degraded by the C&SF Project, which encompasses 4,660,000 ha from Orlando to Florida Bay and includes about 1,600 km each of canals and levees, 150 water control structures, and 16 major pump stations. This system has disrupted the natural volume, timing, quality and distribution of surface and ground water throughout South Florida. In recognition of the detrimental effects that this flood control system has had on the ecosystems in South Florida, numerous hydrologic projects, whose purposes are to aid in the restoration of South Florida's ecosystems, while maintaining flood control, are in varying stages of planning and implementation.

The 1992 Water Resources Development Act (WRDA) authorized the Kissimmee River and the Kissimmee River Headwaters Revitalization Project. In 1994, a Project Cooperative Agreement between the COE and the local

sponsor, the SFWMD, combined the two authorized projects into one project, the Kissimmee River, Florida Project. The purpose of the project is to provide the flows necessary to restore the Kissimmee River ecosystem. We have the ability to increase the spatial extent and quality of foraging habitat available to wood storks by returning the natural functions to the Kissimmee River basin.

The C-111 and Modified Water Deliveries Projects were congressionally authorized in 1994 and 1990, respectively. The purpose of these two projects is to begin the process of restoring freshwater flows into Everglades NP. This will be accomplished by modifying the structures, canals and levees that deliver water to Everglades NP, and by changing the operational schedules. The future breeding success of the wood stork in Everglades NP is closely tied to the success or failure of these two projects. While other aspects of the overall Everglades restoration will be necessary to re-establish pre-drainage-like flows, these two projects will set the precedent for the restoration of South Florida, including the restoration of the prey base available to breeding wood storks in the southern Everglades.

The Experimental Program of Water Deliveries to Everglades NP was authorized in 1983; its purpose is to provide a vehicle to field-test water delivery methods into ENP. Each iterative test builds on the results of the previous tests and is aimed at furthering the goal of restoring, to the extent practicable, the ecological integrity of the native fauna and flora within Everglades NP, including Florida Bay. As operational flexibility increases with the completion of the Modified Water Deliveries, C-111, and other restoration projects, the ability to implement an operational plan that optimizes ecological restoration will substantially increase, and with it, our ability to recover the wood stork in South Florida.

Water supply and water delivery programs are also addressing habitat degradation of wood stork nesting and foraging areas in the Big Cypress basin and in the Corkscew Regional Ecosystem Watershed. The hydrologic restoration of Southern Golden Gate Estates, a 113 square miles rehydration project being jointly designed by the SFWMD and the Corps of Engineers, will provide surface storage and aquifer recharge and water quality enhancement in the Big Cypress Basin.

WRDA further authorized a comprehensive review of the Central and Southern Florida Project. The purpose of the review is to develop a comprehensive plan to restore, preserve, and protect the South Florida ecosystem. This is to be accomplished through the restoration of more natural flows to the southwest coastal areas, including the Big Cypress basin, and through the Everglades NP to Florida Bay. The WRDA of 1996 accelerated this process and calls for a plan to be sent to Congress for authorization by September 30, 1999. This project, in combination with previously authorized projects, should result in the enhancement of nesting and foraging habitat that is necessary for the recovery of the wood stork subpopulations in South Florida.

In addition to hydrologic restoration projects, the State of Florida administers land acquisition programs that may enhance opportunities to restore wood storks in South Florida. The Save Our Rivers program identifies

lands of environmental significance and prioritizes their acquisition. Of these lands identified, the Model Lands and Pennsuco wetlands in Miami-Dade County, the Golden Gate Estate wetlands in Collier County, and CREW wetlands in Lee and Collier counties are of significance to the wood stork for foraging. Public acquisition of these lands will increase our ability to manage them in an ecologically-sensitive fashion. The Conservation and Recreation Lands Acquisition program is an additional program that may provide some opportunities for wood stork recovery in South Florida, and should be acknowledged and incorporated into long-term planning efforts. Nesting habitat should be protected from disturbance and human alteration through purchase into the public lands system, easements, partnerships and private landowner/government assistance and agreements. Watersheds supporting natural nesting habitat should remain unaltered, or be restored to function as a natural system if previously altered.

Lands can be purchased by Federal agencies through section 104 of the Everglades NP Protection and Expansion Act of 1989 (P.L. 101-229) and section 390 of the Federal Agriculture Improvement and Reform Act of 1996 (P.L. 104-127).

The Everglades NP Protection and Expansion Act of 1989 authorized the purchase of lands to be added to the park that encompass approximately 44,379 ha within northeast Shark River Slough (NESS) and the East Everglades. The purchase of these lands and the hydrological improvements to these lands are critical to restoring ecosystem productivity in the southern Everglades and maintaining adequate freshwater inflow to the downstream estuaries along the Gulf of Mexico and Florida Bay. The purchase of these lands is necessary to limit further habitat destruction outside former boundaries and to restore natural water flow patterns that are critical to the long-term viability of the park.

Section 390 of the Federal Agriculture Improvement and Reform Act of 1996, referred to as Farm Bill 390, provides two distinct funding programs for land acquisition to support restoration of the Everglades. The first program provided $200,000,000 to the Secretary of the Interior to conduct restoration activities in the Everglades Ecosystem in South Florida, including acquisition of real property and interests in real property and resource protection and resource maintenance activities. An additional $100,000,000 is available under the Farm Bill 390 authorization from the sale of Federal surplus lands to purchase lands necessary for the Everglades restoration efforts.

The Corkscrew colony in Collier County continues to occasionally produce large numbers of young in South Florida (Table 2). The acquisition or preservation of this colony's habitat and recovery of more natural hydropatterns within the foraging grounds surrounding this colony, are critical to the recovery of wood storks in South Florida. Wood storks nesting at Corkscrew now show a similar pattern of delayed nesting in many years. Private lands initiatives, conservation easements, and mitigation banking should all be considered as viable opportunities for managing these lands.

Ogden (1990) developed a set of management guidelines for the FWS on wood stork nesting, feeding, and roosting habitats. The guidelines recommend

buffer zones that may be necessary to reduce human disturbance of storks in feeding and roosting habitats. These efforts have substantially contributed to the protection of stork habitat, particularly where new developments have been proposed in areas used by storks. The buffer zones recommended in the management guidelines are larger than those recommended by Rodgers and Smith (1995) in their analysis. At the time the guidelines were developed, little empirical data were available on the response of wood storks to human activities. Rodgers and Smith analyzed only three types of human activities: walking, canoeing, and a small motorboat with two persons. They did not evaluate responses to other activities such as construction or aircraft. The current guidelines recommend buffer zones to protect colonies from many kinds of activities including human disturbance. Rodgers and Smith, (1997) study of human disturbance to foraging and loafing waterbirds recommends a buffer of about 100 meters.

An understanding of the relationships between storks and water conditions in the Everglades has provided a basis for restoration planning for the region. Wood storks have been recommended by the Science Sub-Group of the South Florida Ecosystem Restoration Task Force as a species to be used for measuring the success of the overall South Florida Ecosystem restoration. Everglades NP and SFWMD staff have used a 64-year record of stork nesting in the Everglades basin (1932-1995) for this purpose. The C-111 Project, Modified Water Deliveries Project, the Experimental Program of Water Deliveries to Everglades NP, and the regional water management plans being developed for the EAA, the Big Cypress basin and the CREW should eventually result in much improved habitat conditions for storks in South Florida. It is currently assumed, as a part of the restoration planning, that the recovery of increased volumes of freshwater flows through the Everglades marshes and into the estuaries of Florida Bay will increase primary and secondary production in these regions.

Regional surveys of nesting colonies conducted from 1957 through 1961, and again in the mid-1970s, have been essential for locating important habitats, and for understanding the threats to the southeastern population of storks. These surveys were the first to measure the status of the regional population of storks, and have been used to measure responses by nesting storks to water management practices in the Everglades region. Over the 5 years from 1991 to 1995, the FWS coordinated a systematic multi-state survey of stork nesting colonies (L. Finger, FWS, personal communication 1996). The census continued through the 1995 nesting season. After a 5-year hiatus where financial efforts were directed towards research, a new series of censuses began again in the year 1999.

Stangel *et al*. (1990) employed starch gel electrophoretic techniques to examine genetic variation in Florida wood stork colonies. This study did not indicate significant allozyme differences within or between colonies. In 1994, a genetics study incorporating DNA microsatellites of breeding storks in Florida, Georgia, and South Carolina was initiated to further investigate the geographic and genetic origins of wood stork colonies in the three states. By assessing the degree of genetic interrelatedness among wood stork colonies, vital information may be obtained concerning population movements, allowing us to determine whether the increase in numbers of storks breeding in the

northern portion of their range is the result of high productivity in those colonies, increased immigration from Florida colonies, or both. However, the increase in the size and number of "northern" colonies almost certainly occurred too rapidly to be explained by local recruitment.

An effort should be made to place transmitters on juvenile wood storks in South Florida. This will help us to identify critical foraging grounds and gain insight into post-fledging survivorship.

A Wetlands-Wood Stork Summit was held on October 13-14, 1994 in Georgia. The Georgia Conservancy and Zoo Atlanta convened this summit to initiate a coordinated regionwide effort in wetlands education focusing on the wood stork. The initiative would be comprised of both an education and a research component. A grant proposal was submitted in early 1995 requesting support for this effort.

The informal Wood Stork Management Group, formed 3 years ago by the Georgia Conservancy and more recently hosted by the FWS, should continue to meet annually as a means for reviewing trends and assessing the influences of Everglades restoration projects relative to patterns by total stork populations in the Southeast.

Literature Cited

Alho, C.J.R., T.E. Lacher, Jr., and H.C. Gonçalves. 1988. Environmental degradation in the Pantanal ecosystem. BioScience 38:164-171.

American Ornithologists' Union [AOU]. 1983. Checklist of North American birds. Sixth Edition. American Ornithologists' Union; Baltimore, Maryland.

Bancroft, G.T., W. Hoffman, R.J. Sawicki and J.C. Ogden. 1992. The importance of the Water Conservation Areas in the Everglades to the endangered wood stork (*Mycteria americana*). Conservation Biology 6:392-398.

Bent, A.C. 1926. Life histories of North American marsh birds. U.S. National Museum Bulletin 135; Washington, D.C.

Beyer, W.N., M. Spalding, and D. Morrison. 1997. Mercury concentrations in feathers of wading birds from Florida. Ambio 26:97-100.

Brouwer, K., M.L. Jones, C.E. King, and H. Schifter. 1992. Longevity and breeding records of storks. International Zoo Yearbook 31:131-139.

Browder, J.S. 1984. Wood stork feeding areas in southwest Florida. Florida Field Naturalist 12:81-96.

Bryan, A.L. Jr., and M.C. Coulter. 1995. Wood stork use of the Kathwood foraging ponds: 1986-1993. Pages 53-56 *in* R.R. Shortland (coordinator). Proceedings of the wood stork symposium, 19-20 October 1993. The Georgia Conservancy; Savannah, Georgia.

Cato, James C., P. B. Youngberg, and R. Raulerson. 1976. *in* J.C. Cato and E. McCullough (editors). Economics, biology, and food technology of mullet. Florida Sea Grant Program. Report Number 25. August. pp 15-47.

Cone, W.C. and J.V. Hall. 1970. Wood ibis found nesting in Okeefenokee Refuge. Oriole 35:14.

Coulter, M.C. 1987. Foraging and breeding ecology of wood storks in east-central Georgia. Pages 21-27 *in* R.R. Odom, KA. Riddleberger, and J.C. Ozier, eds. Proceedings of the third southeastern nongame and endangered wildlife symposium. Georgia Department of Natural Resources; Atlanta, Georgia.

Coulter, M.C. 1992. Foraging ecology of American wood storks (*Mycteria americana*) in east-central Georgia, USA. Pages 411-416 in Proceedings of the seventh Pan-African Ornithological Congress.

Coulter, M.C. 1996. Revised recovery plan for the U.S. breeding population of the wood stork. U.S. Fish and Wildlife Service; Atlanta, Georgia.

Coulter, M.C., and A.L. Bryan, Jr. 1993. Foraging ecology of wood storks (*Mycteria americana*) in east-central Georgia: Characteristics of foraging sites. Colonial Waterbirds 16:59-70.

Davis, S.M. and J.C Ogden. 1994. Toward ecosystem restoration. Pages 769-796 *in* S.M. Davis and J.C. Ogden, eds. Everglades: the ecosystem and its restoration. St. Lucie Press; Delray Beach, Florida.

Depkin, F.C., M.C. Coulter, and A.L. Bryan, Jr. 1992. Food of nestling wood storks in east-central Georgia. Colonial Waterbirds 15:219-225.

Dusi, J.L., and R.T. Dusi. 1968. Evidence for the breeding of the wood stork in Alabama. Alabama Birds 16:14-16.

Facemire, C.F. and L. Chlebowski. 1991. Mercury contamination in a wood stork. U.S. Fish and Wildlife Service Publication No. VBFO-91-CO3; Vero Beach, Florida.

Finger, L. 1996. Personal communication, 15 October 1996.

Frederick, P.C. 1993. Wading bird nesting success studies in the Water Conservation Areas of the Everglades, 1992. Unpublished draft final report prepared for the South Florida Water Management District in fulfillment of contract No. C3138. South Florida Water Management District; West Palm Beach, Florida.

Frederick, P.C. 1994. Wading bird nesting success studies in the Water Conservation Areas of the Everglades, 1994. Unpublished draft final report prepared for the South Florida Water Management District in fulfillment of contract No. C3138. South Florida Water Management District; West Palm Beach, Florida.

Frederick, P.C. and M.G. Spalding. 1994. Factors affecting reproductive success of wading birds (Ciconiiformes) in the Everglades Ecosystem. Pages 659-691 *in* S.M. Davis and J.C. Ogden, eds. Everglades: the ecosystem and its restoration. St. Lucie Press; Delray Beach, Florida.

Guillette, L.J. Jr., T.S. Gross, G.R. Masson, J.M. Matter, H.F. Percival, and A.R. Woodward. 1994. Developmental abnormalities of the gonad and abnormal sex hormone concentrations in juvenile alligators from contaminated and control lakes in Florida. Environmental Health Perspectives 102:680-688.

Hefner, J.M., B.O. Wilen, T.E. Dahl, W.E. Frayer. 1994. Southeast wetlands: Status and trends, mid-1970s to mid-1980s. U.S. Department of the Interior, Fish and Wildlife Service; Atlanta, Georgia.

Howell, A.H. 1932. Florida bird life. Coward-McCann; New York, New York.

Kahl, M.P., Jr. 1964. Food ecology of the wood stork (*Mycteria americana*) in Florida. Ecological Monographs 34:97-117.

Kahl, M.P., Jr. 1972. Comparative ethology of the Ciconiidae. The wood storks (Genera *Mycteria* and *Ibis*). Ibis 114:15-29.

Klein, H., J.T. Armbruster, B.F. McPherson, and H.J. Freiberger. 1974. Water and the south Florida environment. South Florida environmental proceedings: ecological report number. DI-SFEP-74-75. U.S. Geological Survey; Atlanta, Georgia.

Kushlan, J.A. 1979. Prey choice by tactile foraging wading birds. Proceedings of the Colonial Waterbird Group 3:133-142.

Kushlan, J.A., J.C. Ogden, and A.L. Higer. 1975. Relation of water level and fish availability to wood stork reproduction in the southern Everglades, Florida. U.S. Geological Survey open file report 75-434. U.S. Government Printing Office; Washington, D.C.

Leach, S.D., H. Klein, and E.R. Hampton. 1972. Hydrologic effects of water control and management of southern Florida. Bureau of Geology, Florida Department of Natural Resources; Tallahassee, Florida.

Luthin, C.S. 1987. Status of and conservation priorities for the world's stork species. Colonial Waterbirds 10: 181-202.

Neotropical Bird Club. 1996. Mexico: Stork surveys in Mexico. Neotropical News 1 [Excerpt from Specialist Group on Storks, Ibises, Spoonbills Newsletter 7(1/2) 1995]. Neotropical Bird Club homepage on World Wide Web [http://www.netlink.co.uk/users/aw/nbchome.html].

Oberholser, H.C. 1938. The bird life of Louisiana. Louisiana Department of Conservation, Bulletin 28.

Oberholser, H.C. and E.B. Kincaid, Jr. 1974. The bird life of Texas. University of Texas Press; Austin, Texas.

Ogden, J.C. 1990. Habitat management guidelines for the wood stork in the southeast region. Prepared for the U.S. Fish and Wildlife Service; Atlanta, Georgia.

Ogden, J.C. 1991. Nesting by wood storks in natural, altered, and artificial wetlands in central and northern Florida. Colonial Waterbirds, volume 14: 39-45.

Ogden, J.C. 1994. A comparison of wading bird nesting colony dynamics (1931-1946 and 1974-1989) as an indication of ecosystem conditions in the southern Everglades. Pages 533-570 *in* J.C. Ogden and S.R. Davis, eds. Everglades: the ecosystem and its restoration. St. Lucie Press; Delray Beach, Florida.

Ogden, John C. 1996a. Wood Stork *in* J.A. Rodgers, H. Kale II, and H.T. Smith, eds. Rare and endangered biota of Florida. University Press of Florida; Gainesville, Florida.

Ogden, J.C. 1996b. Personal communication, U.S. Fish and Wildlife Service Multi-Species Recovery Team meeting, 26 April 1996.

Ogden, J.C. 1998. Personal communication, Comments on technical/agency draft multi-species recovery plan for South Florida. September 30. 1998.

Ogden, J.C. 1998. Status of Wading Bird Recovery - 1998. Pages 13-14 *in* D. E. Gawlik, eds. South Florida wading bird report, volume 4, Issue 1, September 1998. South Florida Water Management District. Everglades System Research Division. West Palm Beach, Florida.

Ogden, J.C. and S.A. Nesbitt. 1979. Recent wood stork population trends in the United States. Wilson Bulletin 91(4):512-523.

Ogden, J.C. and B.W. Patty. 1981. The recent status of the wood stork in Florida and Georgia. Pages 97-102 *in* R.Q. Odom and J.W. Guthrie, eds. Proceedings of the nongame and endangered wildlife symposium, August 13-14, 1981. Georgia Department of Natural Resources, Game and Fish Division, Technical Bulletin WL5; Athens, Georgia.

Ogden, J.C., J.A. Kushlan, and J.T. Tilmant. 1976. Prey selectivity by the wood stork. Condor 78(3):324-330.

Ogden, J.C., J.A. Kushlan, and J.T. Tilmant. 1978. The food habits and nesting success of wood storks in Everglades National Park in 1974. U.S. Department of the Interior, National Park Service, Natural Resources Report No. 16.

Ogden, J.C., D.A. McCrimmon, Jr., G.T. Bancroft and B.W. Patty. 1987. Breeding populations of the wood stork in the southeastern United States. Condor. 89:752-759.

Ogden, J.C., Knodler, and A. Sprunt, III. 1988. Colonial Wading Bird Populations in the Usumacinta Y Grijalva. Gobiernodel Estado de Tabasco.

Palmer, R.S. 1962. Handbook of North American birds, Volume 1, Loons through Flamingos. Yale University Press; New Haven, Connecticut.

Rand, A.L. 1956. Foot-stirring as a feeding habit of wood ibis and other birds. American Midland Naturalist 55:96-100.

Rodgers, J.A., Jr. 1990. Breeding chronology and clutch information for the wood stork from museum collections. Journal of Field Ornithology 61(1):47-53.

Rodgers, J.A., Jr. 1996. Population genetics of wood storks in Florida. Final report. Florida Game and Fresh Water Fish Commission. On file at U. S. Fish & Wildlife Service South Florida Field Office, Vero Beach, Florida.

Rodgers, J.A., Jr. 1998. Personal communication. Comments on technical/agency draft multi-species recovery plan for South Florida. September 30. 1998.

Rodgers, J.A., Jr., and Henry T. Smith. 1995. Set-back distances to protect nesting bird colonies from human disturbance in Florida. Conservation Biology 9(1):89-99.

Rodgers, J.A., Jr., and Henry T. Smith. 1997. Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. Wildlife Society Bulletin. 25:139-145.

Rodgers, J.A., Jr., A.S. Wenner, and S.T. Schwikert. 1987. Population dynamics of wood storks in north and central Florida. Colonial Waterbirds 10:151-156.

Rodgers, J.A., Jr., A.S. Wenner, and S.T. Schwiker. 1988. The use and function of green nest material by wood storks. Wilson Bulletin, 100(3); 411-423.

Rodgers, J.A., Jr., S.T. Schwikert, and A.Shapiro-Wenner. 1996. Nesting habitat of wood storks in north and central Florida, USA. Colonial Waterbirds 19:1-21.

Rodgers, J.A. Jr., and S.T. Schwikert. 1997. Breeding success and chronology of wood storks in northern and central Florida, U.S.A. Ibis 139:76-91.

Science Subgroup. 1996. South Florida ecosystem restoration: scientific information needs. Report to the Working Group of the South Florida Ecosystem Restoration Task Force.

Stangel, P.W., J.A. Rodgers, Jr. and A.L. Bryan. 1990. Genetic variation and population structure of the Florida wood stork. Auk 107:614 -619.

Sundlof, S.F., M.G. Spalding, J.D. Wentworth and C.K. Steible. 1994. Mercury in livers of wading birds (Ciconiiformes) in southern Florida. Archives of Environmental Contaminants and Toxicology 27:299-305.

U.S. Fish and Wildlife Service [FWS]. 1997. Revised recovery plan for the U.S. breeding population of the wood stork. U.S. Fish and Wildlife Service; Atlanta, Georgia.

Wayne, A.T. 1910. Birds of South Carolina. Contributions to the Charleston Museum No.1.

Recovery for the Wood Stork

Mycteria americana

Recovery Objective: RECLASSIFY to threatened, then delist.

South Florida Contribution: The former Science Subgroup (now Science Coordination Team) of the South Florida Ecosystem Restoration Task Force and Working Group prepared a set of recommendations for success measures for the South Florida Ecosystem restoration program. Included in these recommendations are targets for the recovery of nesting wading birds in the Everglades basin (WCAs and ENP). The Science Subgroup's measure of success for the wood stork is a breeding population between 1,500 to 2,500 pairs. The goal for wood stork recovery in South Florida is to support 2,500 nesting pairs in the Everglades and Big Cypress Basin systems and to support, as a South Florida Ecosystem component, 35 percent (3,500 nesting pairs) of the southeast United States recovery and delisting nesting population of 10,000 pairs.

Recovery Criteria

South Florida will contribute to the recovery of the total population, if the wood stork foraging and nesting habitat in the Everglades watershed is restored and/or enhanced as a result of the modified water storage and delivery programs being developed by the SFWMD and the COE. The recovery criteria as identified in the wood stork recovery plan, for the Everglades and Big Cypress Basin is a population of 2,500 nesting pairs. The recovery criteria for the South Florida Ecosystem populations, which also includes nesting colonies in coastal counties in central Florida and nesting colonies in the Kissimmee Basin, is 35 percent (3,500 nesting pairs) of the total recovery population of 10,000 pairs.

Species-level Recovery Actions

S1. **Determine the distribution and status of wood storks in South Florida**. All evidence suggests that the wood stork population in the southeast U.S. is a single population, with individuals moving throughout the landscape in response to habitat conditions; the recovery of wood storks depends on the success of the birds throughout their range. Historically, South Florida supported greater than 70 percent of the nesting wood storks in the Southeast. Recent nesting populations in South Florida average around 10 to 13 percent with the major nesting occurring at the Corkscrew colony. More recent data provided by Ogden (1997) also present evidence that South Florida provides winter foraging grounds for many of the recently developed northern breeding colonies in north Florida, Georgia, and South Carolina. The restoration and enhancement of the South Florida foraging habitat is important to the overall

recovery of the wood stork population and the reversal of the decreasing nesting trends in South Florida. Distribution must be monitored into the future to determine wood stork response to Everglades restoration activities.

S1.1. Conduct wood stork annual nesting surveys within the Everglades and Big Cypress Basins and the east and west coast populations. The health and productivity of colonies must be known to evaluate the status and recovery of the wood stork. Long-term wading bird nesting data in South Florida suggest that the number of pairs of birds initiating nesting in a given year is a better indicator of ecosystem health than is nesting success. The number of pairs of wood storks attempting to breed in South Florida should be monitored annually to determine wood stork response to ecosystem conditions in South Florida. Conducting annual nesting surveys within these basins will provide information on annual nesting patterns for wood storks in South Florida and will allow us to best respond with the appropriate management strategies for the species. Much could be learned about wood stork ecology in the Everglades by detailed review of the multi-year systematic reconnaissance flight data. Detailed evaluation of these data is necessary.

S1.2. Locate foraging and roosting habitat. Wood storks take several years to mature to breeding age. The survival of birds during these years is critical. Research that gains a better understanding of where non-breeding birds go in Florida needs to be conducted. Research on what habitats are critical to their survival and what factors may be limiting their survival is also necessary. Identifying important foraging and roosting habitat is critical to the recovery of the wood stork. Recent studies along the Georgia and South Carolina coast have provided valuable information on roosting and foraging behavior (Bryan and Coulter 1995); additional work of this sort is needed in South Florida.

S1.3. Develop standardized census procedures for wood storks nesting in South Florida. Systematic nesting survey protocol should be developed for both the Everglades and Big Cypress basins. This protocol will allow for comparison between years and between basins.

S2. Protect and enhance wood storks in the South Florida Ecosystem through provisions of section 7 of the ESA. The majority of management activities to protect and enhance wood storks in the South Florida ecoregion must occur at an ecosystem level (see habitat-level recovery actions), not a species-specific level; wood storks respond to changing environmental conditions by integrating habitat conditions over a large geographic area and therefore will be more affected by large-scale management practices. However, the review of Federal water management practices through section 7 consultations is one vehicle whose implementation will be imperative to the survival and recovery of the wood stork. Much of the landscape utilized by wood storks in South Florida is subject to Federal and State water management practices; water management of the COE's C&SF project is critical to the survival and recovery of the wood stork. The FWS needs to provide conservation recommendations to enhance habitat conditions for the wood stork throughout the C&SF project. Specific guidance should include operational schedules (water regulation) for Lake Okeechobee, the WCAs, Everglades NP, and Big Cypress National Preserve. The Kissimmee River basin also supports important colonies of wood storks. The water management goals of the Kissimmee River basin may affect foraging and nesting success in these colonies. Proposed land management actions on these restoration lands need to be examined in relation to wood stork habitat requirements.

S3. Conduct research on the biology and life history of wood storks. Recovery efforts for wood storks will be more effective with a complete understanding of population biology, movement patterns, foraging ecology and behavior, the importance of roost sites, and the possible impacts of contaminants on South Florida wood storks. To date, information on nesting patterns and the number of wood storks initiating nesting in South Florida has been collected for some regions in some years. Additional information is needed on wood stork demographics and movement patterns between the colonies and foraging and roosting sites.

S3.1. Determine the productivity of wood storks nesting in South Florida. To estimate the productivity of wood storks, the number of fledged young per nest and the number of fledged young per successful nest must be determined for the major nesting colonies in South Florida during the same breeding cycle.

S3.2. Determine survivorship of wood storks in South Florida. This parameter is one of the least understood, and research on this topic may provide more new insights into population dynamics than any other effort. We need to determine survivorship of fledged young to adulthood to better gauge what amount of productivity is required to maintain or increase wood storks nesting in South Florida. This might be accomplished through a massive multi-year leg banding (or wing tagging) effort in multiple colonies, radio-instrumenting a certain number of birds (with mortality sensors) or possibly by surveys during the non-breeding season to determine the adult:sub-adult ratio.

S3.3. Determine the age structure of the wood stork population in the southeast U.S. This information will be necessary to determine whether the population is sustainable and can be delisted.

S3.4. Determine the movement patterns of South Florida wood stork fledglings and post-breeding South Florida adult wood storks. Movement patterns will provide information on behavior, habitat utilization, and potential critical foraging areas. The survival of fledgling wood storks is dependent on their ability to find suitable foraging areas when they first begin to forage independently. If fledglings must travel great distances to forage, their survival may be hampered. Additionally, understanding the movement patterns of adult wood storks after they complete breeding will answer questions such as: 1) Do adult wood storks “help” fledglings to find suitable foraging sites, and 2) Are there foraging sites within a “critical” distance from breeding colonies in South Florida, or do adult storks, upon completion of breeding, move out of South Florida?

S3.5. Determine foraging ecology and behavior of wood storks. The number of wood storks nesting in South Florida has greatly declined. Information on foraging by wood storks in South Florida needs to be completed to determine the inter-dependence of successful nesting by wood storks in South Florida and the availability of suitable foraging sites. Information from the systematic reconnaissance flights should provide information on foraging distribution for multiple years and should help to answer some questions on the foraging ecology of the wood stork, but additional work must be completed to understand the characteristics of the forage base that are necessary to provide functional wood stork foraging habitat in South Florida.

S3.5.1. **Re-evaluate wood stork foraging studies in Everglades NP**. Studies on the forage base available and utilized by storks in Everglades NP were done in the 1970s. A comparative study should be completed to determine if changes have occurred in the prey base available to wood storks. This issue should again be addressed since this ecosystem is vital to recovery goals, is important as a wintering area for all storks, and has recently been documented to have problems with mercury contamination (Sundlof *et al.* 1994).

S3.5.2. **Conduct studies on the prey base available in areas identified as critical foraging sites during the breeding season.** We need to collect information on the prey base available to wood storks at foraging areas receiving high use during the breeding season. This information should be compared to identical information collected at sites not utilized by wood storks during the same time period.

S3.5.3. **Determine foraging requirements of wood storks during the non-breeding season.** Research concerning the foraging ecology of this species should also examine foraging requirements during the wintering or non-breeding period. In some years, the inland marshes of the Everglades have supported the majority of the U.S. population of wood storks. During the non-breeding seasons in 1985 to 1989, up to 55 percent of the entire U.S. population may have relied on the WCAs (which comprise only a portion of the Everglades system) to meet their foraging requirements (Bancroft *et al.* 1992). Understanding the processes that determine whether storks in the non-breeding season are concentrated on a small area of habitat or dispersed throughout their entire winter range will provide management flexibility and decrease the likelihood of negative impacts to a large proportion of the population during a single season.

S3.5.4. **Continue studies on wood stork nocturnal foraging activities.** Preliminary studies by Bryan (1995) indicate that storks in South Carolina and Georgia are active nighttime feeders. The prevalence of nocturnal foraging activities by this species needs to be studied both seasonally and geographically in South Florida. Nocturnal feeding may be more important for wood storks feeding in tidal marshes than in freshwater marshes, but, if nocturnal feeding by wood storks is significant, regulatory decisions may need to reflect this information to protect wood stork foraging grounds from disturbance "around the clock".

S3.6. **Determine the importance of wood stork roost sites.** Recent surveys of the Georgia and South Carolina coast documented the presence of a large number of stork roost sites, but only a limited number of roosts were inhabited repeatedly by numerous storks. Research concerning the function and use of such sites and habitats in South Florida is needed. If important roost sites are identified in South Florida, protective measures should be developed. These studies could also assess foraging habitats utilized from these sites, thus providing important information about the non-breeding season.

S3.7. Determine the impacts of contaminants on wood storks in South Florida. Potential impacts from contaminants need to be reconsidered in light of recent findings concerning the amount of mercury present in the Everglades Ecosystem and the discovery of severe impacts of DDT/DDE-based estrogen-mimicking compounds on wildlife in a large Florida wetland (Guillette *et al.* 1994).

S3.7.1. Conduct mercury studies on wood storks in South Florida. Studies should be conducted in the South Florida E cosystem to document effects of mercury on wood storks.

S3.7.2. Conduct contaminant studies on wood storks throughout the region. Develop baseline contaminant information from a variety of colony sites throughout the region to determine if further studies are needed.

S3.8. Complete models for the wood stork population. Population viability assessment and risk analysis models should be performed for the wood stork population once the necessary information is acquired. Once completed, the relative importance of the South Florida Ecosystem, and the ability of the wood stork to successfully breed in South Florida, should be determined.

S3.9. Develop models of wood stork colony dynamics in South Florida wetlands. These models are needed as planning tools for improved ecosystem restoration programs. Potentially one important ecological model for the Everglades is a wood stork population dynamics model that is a part of the "Across-Trophic-Level System Simulation" (ATLSS) set of models being developed by the South Florida/Caribbean Field Station of the USGS, BRD.

S4. Monitor wood storks in South Florida. Annual nesting and foraging surveys should be completed for wood storks in South Florida. These surveys will provide the information necessary to monitor the success of ecosystem and species-specific recovery actions. Surveys should be performed on an annual basis within both the Everglades and Big Cypress basins until the species is delisted.

S4.1. Conduct long-term monitoring of the number of wood storks initiating nesting in South Florida, as described by tasks 1.1. and 1.2.

S4.2. Organize systematic censuses of wood stork foraging habitat in the Big Cypress region, comparable to existing censuses (systematic reconnaissance flights) in the Everglades basin. The fact that declines in nesting effort and delays in timing of colony formation have shown similar trends in the Big Cypress basin have been well documented in the Everglades basin suggests that the Big Cypress colonies are dealing with similar kinds of habitat deterioration on the foraging grounds. The location and relative importance of stork foraging grounds in the Big Cypress basin are much less known, and should be determined as a basis for developing protection strategies in this region; this survey would provide the information necessary to monitor the success of both ecosystem and species-specific recovery actions.

S4.3. Continue foraging surveys in the Water Conservation Areas and Everglades NP. This information is necessary to follow the trends of wood storks in South Florida and should be continued until the species is delisted.

S4.4. Initiate and continue demographic surveys, such as colony surveys to determine productivity; additionally, studies to determine survivorship should be continued until

enough data have been collected to determine wood stork rates of growth, reproduction, and survival. This information will be critical to determine whether or not the species can be delisted.

S5. Increase public awareness. Wood storks are an indicator species of the Everglades Ecosystem; the health of the Everglades can be measured by the ability of the wood stork to successfully breed in the Everglades. The Maine coastal seabird colony restoration program uses the puffin as its symbol. The wood stork is a symbol of the health of the Everglades and Big Cypress basins and could be used as a barometer of the success of Everglades restoration projects.

S5.1. Increase awareness and appreciation of wood storks through educational materials. Wood storks utilize a variety of wetland habitats and have been identified as an indicator species for the Everglades. Additionally, they are visually unique and generate interest from the general public. Make the wood stork a symbol of the Everglades through the use of environmental education materials and programs.

S5.1.1. Develop and distribute educational materials. Currently, there are several brochures, videos, and educational packets available that focus on wood storks. This information needs to be kept up to date. New educational material should be developed to increase the awareness of a larger audience.

S5.1.2. Develop information for private landowners. Wood storks breeding in the Corkscrew Swamp and in the northern and central Big Cypress basin in South Florida forage in surrounding wetlands, many of which are on private lands. Material explaining wood stork ecology and suggesting management practices benefiting storks should be distributed to private landowners.

S5.1.3. Develop educational materials for schools. Since wood storks occur in Florida, Georgia and South Carolina, it would be cost-effective to develop educational materials that could be used in schools in all three states.

S5.1.4. Develop material for policy makers and elected officials. The wood stork should be included as part of a larger effort to inform and educate South Florida policy makers and elected officials of the importance of maintaining and protecting wetland habitats throughout the Big Cypress and Everglades basins.

S5.2. Provide opportunities for the public to view wood storks in captivity. Maintaining wood storks in captivity should be for the sole purpose of public education, awareness, and research to enhance survival of the species. Currently, there are nearly two dozen American wood storks in captivity in North American zoos and related facilities.

S5.2.1. Maintain captive populations for the purpose of education, awareness, and research. FWS draft policy on controlled propagation sanctions captive propagation of listed species when recommended in an approved recovery plan and supported by an approved genetics management plan. Captive propagation of wood storks is not considered necessary for the purpose of supplementing wild populations through

reintroduction programs. Captive breeding and rearing efforts will not be made for this purpose. However, good captive management of wood storks may result in reproduction. The resulting progeny may be used to supplement other captive populations under approval of the FWS. If available space within captive facilities becomes saturated, further production of offspring should be prevented within the scope of laws governing captive endangered wildlife.

S5.2.2. Develop policy on rescue, rehabilitation and release of injured wood storks. The FWS, in conjunction with the American Zoological Association, should develop a policy for dealing with wood storks that are rescued from the wild. Adult wood storks are not as frequently received by licensed wildlife rehabilitators as other wetland bird species. Opportunities for rescue may most likely occur when field personnel are in the colonies and witness distress. This may be as a result of nest abandonment when food sources become scarce or when chicks fall out of the nest for reasons such as adult bird interactions or wind storms. Where possible, field personnel should return downed chicks to the nest. When replacement is not viable, the usual protocols for triage and rehabilitation should be followed in placement with a licensed wildlife rehabilitator.

Habitat-level Recovery Actions

H1. Prevent degradation of existing wood stork habitat in South Florida through identification and protection. At a minimum, for continued survival of the U.S. population, currently occupied nesting, foraging, and roosting habitat in South Florida must be protected from further loss or degradation. Watersheds supporting natural nesting habitat should remain unaltered, or be restored to function as a natural system if previously altered.

H1.1. Create distribution maps of important wood stork colony, foraging, and roosting sites in South Florida for protection and restoration. Important colony sites have been identified for the WCAs and Everglades NP. However, colony sites in the Big Cypress basin are not as well known. Very little is known about roosting sites in South Florida. Identifying all important colony sites, roosting sites, and foraging habitat is critical to the recovery of the wood stork. A GIS database should be developed from data collected by colony, roosting, and foraging surveys, as delineated by species-specific tasks **S1.1** and **S1.3**; a GIS database will aid recovery biologists in targeting areas in need of protection, restoration, or management, and will allow managers and private landowners to more efficiently protect and manage these lands for wood storks.

H1.2. Prioritize habitats that need protection. Develop a prioritization scheme to focus protection and restoration efforts on colonies and feeding sites with the greatest degree of threat. Efforts should be made to identify important foraging and roost sites associated with high priority colonies.

H1.3. Work with private landowners to protect habitat. Conservation agencies need to recognize the significant contributions that private landowners can make for the protection of wood storks. For example, many of the foraging grounds utilized by storks breeding at the Corkscrew colony in South Florida are in private ownership

and are threatened by conversion to citrus farming; the future success of this colony is dependent on maintaining viable foraging habitat within the region.

H1.3.1. Inform landowners. Inform all landowners having critical foraging and roost sites (as defined in task **H1.2**.) on their properties. Encourage compliance with existing regulatory mechanisms (see task **H1.6.**).

H1.3.2. Provide assistance and support to landowners in managing their property for the benefit of wood storks. Assistance can be in the form of written material explaining best management practices, site visits, local recognition, tax and/or monetary incentives. State and Federal agencies should work with private landowners in an effort to incorporate wood stork feeding habitat into current management practices.

H1.3.3. Develop management plans for private lands. Conservation agencies should assist landowners in developing specific management plans for their properties. These management plans should adequately protect sites yet be flexible enough to respond to the changing needs of the landowner. The success or failure of management prescriptions for nesting, roosting, and foraging areas should be clearly documented and reported.

H1.4. Protect sites from disturbance. The FWS developed habitat management guidelines for wood storks (Ogden 1990) in an effort to reduce disturbance to colony sites. These management guidelines discuss various types of activities known to disturb nesting wood storks. Additionally, certain types of habitat management activities can adversely impact colony sites. Cypress logging is a potential threat to some colonies. Human disturbance causes wood storks to leave nests, exposing eggs to predation and exposure. Posting or other appropriate protection may provide some benefit to storks nesting or foraging within the Big Cypress and Everglades basins.

H1.5. Use existing regulatory mechanisms to protect foraging habitat in South Florida. The central and northern Big Cypress basin historically supported large numbers of nesting wood storks. Presently, much of this historic range is being converted to citrus and pasture for cattle grazing. Coordinated efforts should also be used to seize opportunities to provide enhanced feeding areas through the mitigation process.

H1.5.1. Review Federal actions for impacts to wood storks. Wetlands are altered for mining, agriculture, and residential purposes. Permitting authority over such activities is held by local governments, agencies in the State of Florida (DEP, SFWMD) and the Federal government (COE, EPA). Important feeding areas should be included as a category of waters for which the FWS receives COE pre-discharge notification pursuant to section 404 of the Clean Water Act. section 7 of the Endangered Species Act requires that all Federal agencies ensure that their actions are not likely to jeopardize the continued existence of any listed species or destroy or modify their critical habitat. Federal agencies conducting actions that may affect the continued existence of wood storks must consult with the Service.

H1.5.2. Encourage conservation of wood stork habitat in conservation plans. Section 10(a) (1)(B) of the Endangered Species Act provides for incidental take permits that have the potential to contribute to the

conservation of listed species. If appropriate, applicants should be encouraged to consider conservation of wood stork habitat when preparing Habitat Conservation Plans.

H2. Restore and enhance habitat. A prerequisite for the recovery of wood storks in the southeastern United States is the restoration and enhancement of suitable habitat throughout the mosaic of habitat types used by this species. Historically, South Florida supported greater than 70 percent of the nesting by wood storks in the Southeast. The deterioration of the Everglades and Big Cypress basins has resulted in decreased nesting by wood storks in South Florida and increased nesting in northern Florida, Georgia, and South Carolina.

H2.1. Restore the South Florida Ecosystem. Recover traditional Everglades and Big Cypress colony locations. The water delivery formula and schedules developed by the Experimental Water Deliveries Program, the structural modifications to canals and levees proposed for ecosystem restoration of Everglades NP through the Modified Water Deliveries and C-111 Projects, and the regional Everglades restoration planning process (C&SF Restudy) conducted by the COE, should address the recovery of the ecological processes that made it possible for the pre-drainage Everglades basin to support large numbers of storks and other wading birds. These ecological processes were made possible by the large spatial scale of the pre-drainage Everglades, the strong between-year variation in surface water patterns, and the strong flows of surface water into the estuaries.

H2.1.1. Reevaluate the effectiveness of all authorized projects on restoring habitat in the Everglades basin. The Southern Everglades Restoration Alliance (SERA), a group of cooperating agencies, was created to oversee the implementation of authorized ecosystem restoration projects associated with the C&SF Project. SERA is presently re-evaluating projects in the southern Everglades for their effectiveness in ecosystem restoration. The FWS should be involved in project evaluations, and should determine whether recovery efforts will improve habitat conditions for the wood stork. If any authorized projects are found to lack the necessary components (including the appropriate operational schedules and regulatory components) to increase the ability of the wood stork to successfully nest or forage in South Florida, the FWS should help in the development of alternative designs that maximize ecosystem benefit.

H2.1.2. Develop operational criteria that re-establish hydropatterns of the pre-drainage system. Operational schedules will be the most important component of Everglades restoration efforts. Operational schedules must truly balance the needs for flood protection with those of the Everglades ecosystem.

H2.1.3. Restore the timing of nesting by wood storks in the southern Everglades through ecosystem restoration measures. Develop a restoration plan that includes the necessary addition or removal of structures, levees, and canals, to restore hydropatterns throughout the Everglades system; depths, period of inundation and sheetflow patterns should more closely match those of the pre-drainage system.

H2.1.4. Provide feedback for adaptive restoration planning. Monitor stork colony patterns during implementation and testing of future efforts to improve hydrologic conditions. Use information on the location, timing, size and success of stork colonies in the Everglades and Big Cypress basins to evaluate ecological responses to the restoration programs and as a basis for designing future iterations in the restoration process.

H2.1.5. Analyze and report on existing record of stork colony patterns in the Everglades basin, including the effects of initial restoration programs on the ecological recovery of Everglades NP. A report should be completed that incorporates all stork colony data from the Everglades basin and which assesses the impacts of past and current restoration programs, such as the Experimental Program of Water Deliveries to Everglades NP, on wood stork and wading bird colony patterns in Everglades NP; this report should be used to evaluate restoration efforts to date, and to improve future restoration programs.

H2.2. Protect and enhance wood stork foraging habitat in private ownership in South Florida through partnership agreements. Historically, South Florida supported greater than 70 percent of the wood stork nesting effort in the southeast U.S.; the number of wood storks nesting in South Florida has been reduced to a fraction of the historic number. Every effort should be made to protect and enhance that portion of the population that continues to breed and winter in South Florida. For example, the Corkscrew Swamp colony has consistently supported a significant number of nesting wood storks in South Florida. Many of the surrounding wetlands used for foraging by wood storks in this colony are in private ownership and are in danger of being converted to other land uses, such as citrus farming. Protecting these wetlands will be critical to protect the Corkscrew colony and help to preserve wood stork colonies in South Florida.

H2.3. Acquire land identified as important habitat for wood storks in South Florida. Federal and State conservation agencies and private conservation organizations should continue efforts to acquire important habitat utilized by wood storks in South Florida. Initial land acquisition efforts should be carefully targeted to sites having the greatest potential for maintaining storks over time. Large, stable colonies that are in immediate threat from disturbance either through direct threat to the colony site or through a loss of surrounding foraging habitat, should be of highest priority. Priority should also be given to larger colonies with a history of annual use, sites most in need of management, and colony sites where alternate habitat is not available.

H3. Conduct research on the critical habitat components necessary to trigger successful nesting by wood storks in South Florida. We do not know what specific habitat characteristics are necessary to trigger nesting by wood storks in South Florida. Wood storks could be responding to a suite of habitat characteristics such as water depth, photoperiod, rainfall patterns, prey densities, *etc*. Projects should be completed that will help to identify some of these habitat characteristics.

H3.1. Determine the densities, species composition and size classes of fishes necessary to result in successful nesting by wood storks in South Florida. Use information gathered in task **S3.5** (species-level) to establish study locations. Water management practices may have resulted in fish populations that no longer represent “natural”

populations. This information may aid us in developing the appropriate operational criteria for the Everglades restoration. It will also establish a baseline from which to compare the effects of ecosystem restoration activities.

H3.2. Determine the effects of natural and human-caused hydrologic events on the ecology of the prey base utilized by wood storks in South Florida. This information can be used to determine the optimal operational schedules for South Florida's public lands.

H3.3. Determine if reduced freshwater flows into the northern Florida Bay mainland estuaries, as a result of the South Dade Conveyance System and the Experimental Program of Water Deliveries to Everglades NP, have caused wood storks to delay nesting in South Florida. These mainland estuaries historically provided important early dry season foraging habitat; reduced freshwater flows may have significantly altered available prey base.

H4. Monitor the status of areas identified as important wood stork habitat in South Florida. Monitor habitats identified by task **H1.1**. annually to determine whether changes are occurring in response to management actions. For example, habitats likely to be affected by hydrologic restoration projects should be monitored to determine impacts, both beneficial and adverse, on wood storks. The appropriate management decisions need to be considered, discussed, and implemented if adverse impacts are detected.

H5. Increase public awareness about wood storks as an indicator of the health of the Everglades Ecosystem. Educational materials should be developed that identify the importance of the wood stork as an indicator of the health of the Everglades Ecosystem. This information will be key to gain the necessary public support for the restoration of the Everglades. The wood stork is a highly visible component of the Everglades and is perfect to serve as an indicator species to the public.