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RECENT WOOD STORK POPULATION TRENDS IN THE UNITED STATES

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The population of Wood Storks (*Mycteria americana*) resident in the United States occurs on the coastal plain of the Gulf of Mexico and the southern Atlantic states. Historically, storks nested in all coastal states from Texas to South Carolina (Bent 1926, Cone and Hall 1970, Dusi and Dusi 1968, Howell 1932, Oberholser 1938, Oberholser and Kincaid 1974, Wayne 1910), although colonies outside Florida formed irregularly and contained few birds. The United States population of storks was not greatly disturbed during the plume-hunting era (Allen 1958), and probably contained between 75,000 and 100,000 birds of all age classes during the early twentieth century (Ogden 1978). Increased land development and the associated drainage of freshwater wetlands eliminated many nesting and feeding sites, resulting in a severe decline in the total number of storks. Concern for the fate of this species in the United States was first expressed during the late 1950s (Allen 1958, Sprunt and Kahl 1960).

A series of aerial surveys was conducted between 1957 and 1960, in an attempt to locate all remaining Wood Stork nesting colonies in the United States. Renewed concern for the status of storks during the early 1970s resulted in a second series of aerial surveys beginning in 1974. These 2 surveys produced the first complete counts of the number of storks nesting in the United States, and revealed that major colonies continued to decline between surveys. In this paper we present the results of the aerial surveys and discuss probable reasons for the Wood Stork decline to call attention to the seriously threatened status of this species in the United States.

METHODS

One or more aerial surveys were made during breeding seasons over all of peninsular Florida annually between 1957 and 1960, and again between 1974 and 1976. The surveys checked all known or suspected stork nesting colonies and systematically searched for unknown colonies in regions where habitat appeared suitable or where numbers of feeding storks were known. Wood Storks construct large nest platforms in the upper layers of woody vegetation, thus nests are conspicuous from the air. Although we believe that aerial estimates of pairs in colonies are accurate, verification was attempted at most colonies during both series of surveys by ground counts of nests. Aerial surveys and verification during 1957–1960 were conducted by Alexander Sprunt, IV and M. Philip Kahl of the National Audubon Society, and John Storer and Lisa Von Borowsky of the Florida Audubon Society. The 1974–1976 surveys of central and southern Florida were conducted primarily by Ogden, while the northern Florida and Georgia colonies were checked by Nesbitt.

TABLE 1

PAIRS OF NESTING WOOD STORKS IN UNITED STATES COLONIES, 1959–1960, AND 1975–1976

Colony	1959	1960	Colony	1975	1976
Guano Lake	50	50	Craven Hammock	0	16
River Styx[1]	450	150	River Styx	100	70
Panasoffkee	125	120	Dee Dot	85	125
Croom	325	300	Croom	85	0
Lacoochee	0	40	Cabbage Swamp	?	45
Panther Point	40	120	Lake Yale	150	110
Tenoroc	120	10	Turnbull	100	50
Pelican Island	2	0	Pelican Island	275	160
Reedy Creek	215	200	Moore Creek	150	225
Charlie Creek	175	35	Little Gator Creek	(active)	150
Barley Barber	?	200	Mulberry	(active)	450
			Payne Creek	0	4
			Cypress Creek	75	40
			El Clair	0	250
Central-North totals	1502	1225		1020 (1620)[2]	1695
Corkscrew	4000	4700	Corkscrew	3000	2100
Sadie Cypress	5	1400	Sadie Cypress	27	40
Deep Lake	150	0	Lane River	1100	1200
Rocky Lake	0	235	Madeira	125	0
East River	1000	1500	East River	110	75
Cuthbert	1000	1000			
South-west totals	6155	8835		4362	3415
Totals	7657	10,060		5382 (5982)[2]	5110

[1] Also known as Micanopy.
[2] Adjusted total derived from 1976 counts.

RESULTS AND DISCUSSION

Kahl (1964) identified 3 regions of Florida where Wood Storks nest, the Everglades-mangrove, Big Cypress, and Lake districts. Because of strong similarities in seasons of activity and recent population trends between the Everglades and Big Cypress districts, we have combined these 2 into a Southwest Florida region. Also, we have re-named Kahl's "Lake District" as the Central-North Florida region, to include all of Florida and southern Georgia north of Lake Okeechobee. We do not consider storks nesting within a region to represent a distinct subpopulation. Colonies in the Southwest Florida region usually form each year between November

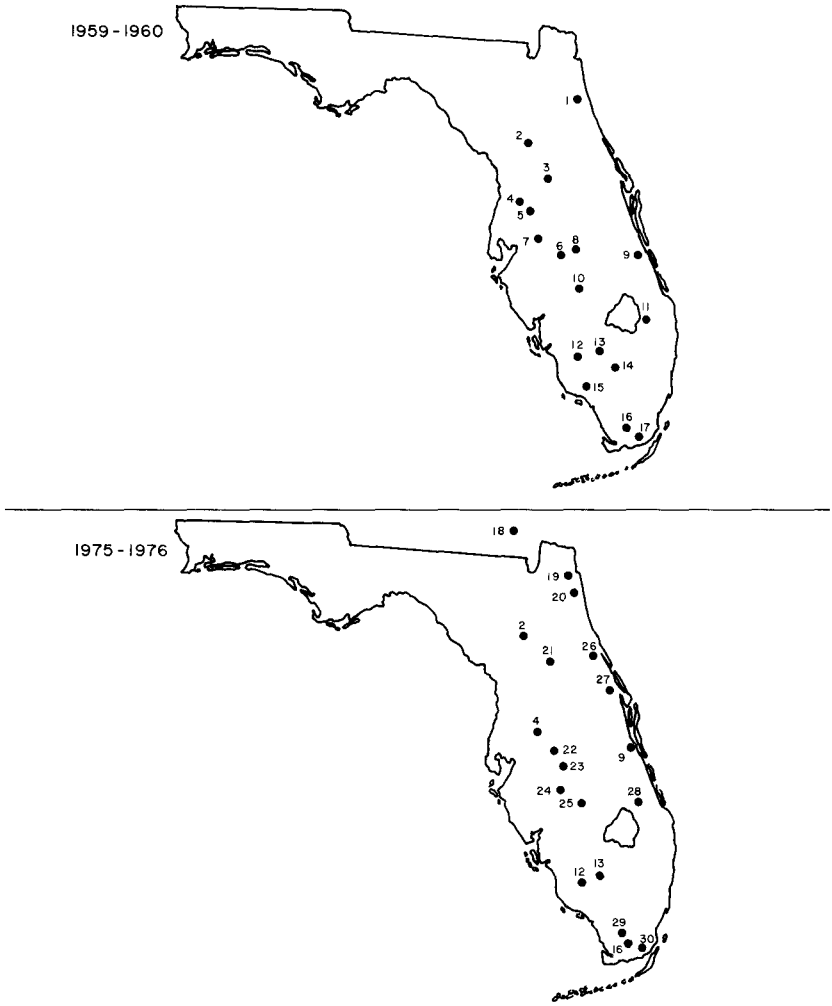

FIG. 1. Location of active Wood Stork colonies during 1959–1960 and 1975–1976 surveys. Numbered sites are as follows: (1) Guano Lake, (2) River Styx, (3) Panasoffkee, (4) Croom, (5) Lacoochee, (6) Panther Point, (7) Tenoroc, (8) Reedy Creek, (9) Pelican Island, (10) Charlie Creek, (11) Barley Barber Cypress, (12) Corkscrew, (13) Sadie Cypress, (14) Rocky Lake, (15) Deep Lake, (16) East River, (17) Cuthbert, (18) Craven Hammock, (19) Dee Dot Ranch, (20) Cabbage Swamp, (21) Lake Yale, (22) Little Gator Creek, (23) Mulberry, (24) Payne Creek, (25) El Clair, (26) Turnbull Slough, (27) Moore Creek, (28) Cypress Creek, (29) Lane River, (30) Madeira.

and January, while Central-North Florida colonies form between February and April. In both regions, colony formation occurs during annual dry seasons, when water levels normally drop and food resources are concentrated (Kahl 1964, Kushlan et al. 1975).

The numbers of breeding pairs of Wood Storks in the United States population during the 2 series of surveys are presented in Table 1. Locations of active colonies are shown in Fig. 1. Counts made during the last 2 years of each survey period were the most accurate because of the cumulative improvement in technique and knowledge of nesting localities; only these data are used in this report. The colonies at Mulberry and Little Gator Creek were active in 1975 but not surveyed. Assuming that the 2 sites contained approximately the same numbers in 1975 as in 1976, as suggested by reports of local observers, we parenthetically included an adjusted 1975 total which we believe is more accurate. Results of the 1974 survey, and of partial surveys in 1972 and 1973, were presented by Ogden (1972, 1973, 1974) and Nesbitt (1973).

Table 1 shows that the overall number of breeding storks in the United States declined 41% in the 15 years between the high counts of 1960 and 1975. On a regional basis, the 2 year mean in the Central-North region increased between the 2 series of surveys by 17% (1363 to 1657 pairs), while the 2 year mean in Southwest Florida declined 48% (7495 to 3888 pairs).

We found the number of pairs nesting in all colonies within a region was greater during some years than others, implying that inter-region feeding conditions and weather are more favorable in some years than others and that not all adult storks attempt nesting in the poorer years. To determine the total number of breeding pairs of storks in the population during each of the surveys, therefore, requires that each survey period contain a favorable year when most adults are in colonies and can be counted. The annual climatological pattern that appeared to stimulate the heaviest nesting efforts by storks was a combination of average or above-average rainfall during the summer rainy season prior to colony formation, and an absence of unusually rainy or cold weather during the following winter–spring nesting season. This pattern produced widespread and prolonged flooding of summer marshes that maximized production of freshwater fishes, followed by steady drying that concentrated fish during the dry season when storks nest (Kahl 1964). Recent studies in south Florida show that since the 1960s the Everglades and Big Cypress ecosystems have produced large numbers of young storks only in years with exceptionally dry winter and spring seasons (Kushlan et al. 1975, Browder 1976).

Pertinent rainfall data for the 1959, 1960, 1975 and 1976 nesting seasons are presented in Table 2. These data show an acceptable wet summer–

TABLE 2
SEASONAL RAINFALL PATTERNS AT 7 FLORIDA STATIONS[1]

Station	Prior to 1959 nesting		Prior to 1960 nesting		Prior to 1975 nesting		Prior to 1976 nesting	
	June–Oct. 1958 rainy season	Nov.–Feb. 1958–59 dry season	May–Oct. 1959 rainy season	Nov.–Feb. 1959–60 dry season	June–Oct. 1974 rainy season	Nov.–Feb. 1974–75 dry season	May–Oct. 1975 rainy season	Nov.–Feb. 1975–76 dry season
Jacksonville	−9.74	+5.91	−7.69	+1.00	+5.38	−5.12	−3.43	−5.22
Gainesville	−3.87	+4.38	+1.98	−1.52	+3.71	−2.23	+0.33	−3.91
Orlando	−7.40	+4.99	+3.98	+1.90	+4.30	−6.42	+4.60	−6.32
Lakeland	−11.63	+3.17	+2.71	−0.07	+5.28	−5.66	−2.61	−3.61
Ft. Pierce	−8.34	−0.86	+13.11	+3.81	+4.71	−6.75	−5.78	−2.73
Ft. Myers	−2.60	+2.03	+8.93	+1.80	+12.36	−5.82	+5.14	−3.69
Miami	−6.23	+6.70	+21.43	+8.74	−5.99	−0.38	−13.24	−0.73
Mean deviation	−7.11	+3.76	+6.35	+2.23	+4.25	−4.62	−2.14	−3.74

[1] Expressed as the cumulative of monthly deviations above (+) or below (−) average rainfall, in inches; data from National Oceanic and Atmospheric Administration.

dry winter pattern of rainfall before and during the 1960 nesting season, and an especially favorable wet–dry rainfall pattern during the 1975 nesting season. We assume that counts of nesting storks during these 2 seasons should include most of the adult birds in the 2 regions. For the south Florida colonies, which have been monitored most consistently, it is known that the number of storks that attempted to nest in 1975 in the Southwest Florida region was greater than during other years of the 1970s (J. Hansen, J. Ogden, pers. obs.).

The kinds of sites used by nesting storks are shown in Table 3. Each colony is categorized by the dominant vegetation where nests were located, whether the colony used a natural site or one altered by past human activity, and whether the site appeared secure from harmful intrusion by humans. We considered a colony to be secure if the land owner was aware of the colony, if human intrusion into the colony was controlled, and the colony site did not appear subject to future physical change due to an action of the owner.

All active colonies seen during the 1974–1976 surveys were in trees over standing water, or on islands. Thus the kind of altered sites acceptable to nesting storks were mainly artificial water impoundments where large trees were left standing. All altered sites were in the Central-North Florida region. Two altered sites contained approximately 10% of the pairs in the Central-North Florida region in 1959 and 1960, 4 altered sites contained 46% of the region's storks in 1975, and 6 altered sites contained 59% in

TABLE 3
GENERAL CHARACTERISTICS OF WOOD STORK NESTING COLONIES

	Location	Dominant vegetation	Natural or altered site	Status-ownership
1959–1960 colonies	Guano Lake	Cypress	Natural	Secure-private
	Panasoffkee	Cypress	Natural	Insecure-private
	Lacoochee	Cypress	Natural	Insecure-private
	Tenoroc	Dead Cypress	Water impoundment	Secure-private[1]
	Panther Point	Dead hardwoods	Water impoundment	Secure-private[1]
	Reedy Creek	Cypress	Natural	Insecure-private
	Charlie Creek	Cypress	Natural	Insecure-private
	Barley Barber	Cypress	Natural	Insecure-private
	Deep Lake	Cypress	Natural	Secure-private
	Rocky Lake	Cypress	Natural	Insecure
	Cuthbert	Mangrove	Natural	Secure-Federal
Active both years	River Styx	Cypress	Natural	Insecure-private
	Croom	Cypress	Natural	Insecure-private
	Pelican Island	Mangrove	Natural	Secure-Federal
	Corkscrew	Cypress	Natural	Secure-Audubon
	Sadie Cypress	Cypress	Natural	Insecure-private
	East River	Mangrove	Natural	Secure-Federal
1975–1976 colonies	Craven Hammock	Cypress	Natural	Secure-Federal
	Dee Dot	Cypress	Water impoundment	Secure-private
	Cabbage Swamp	Cypress	Natural	Insecure-private
	Lake Yale	Cypress	Natural	Insecure-private
	Turnbull	Cypress	Natural	Insecure-private
	Moore Creek	Mangrove	Natural	Secure-Federal
	Little Gator Creek	Cypress	Backwater pumping	Insecure-private
	Mulberry	Dead hardwoods	Water impoundment	Insecure-private
	Payne Creek	Dead hardwoods	Water impoundment	Insecure-private
	El Clair	Cypress	Water impoundment	Secure-private
	Cypress Creek	Cypress	Water impoundment	Insecure-private
	Madeira	Mangrove	Natural	Secure-Federal
	Lane River	Mangrove	Natural	Secure-Federal

[1] Became Florida Audubon Society sanctuaries in December 1959.

1976. The percentage of storks nesting at secure sites was 72% in 1960 and 80% in 1975.

Before action can be taken to stabilize the remaining Wood Stork population, it is necessary to understand the causes for the recent decline. Population stability is dependent upon maintenance of suitable nesting sites, and on the extent and productivity of wetland feeding sites. We know of no other factors that have had an important role in the recent

dynamics of storks in Florida. No pesticides or other environmental pollutants have been shown to have affected reproduction rates or total numbers of fish-eating birds in Florida (Blus et al. 1974, Ogden et al. 1974). Shooting of storks is rare. Most storks remain in Florida during non-breeding seasons, although hundreds disperse northward in some summers, primarily into coastal Georgia and South Carolina (Ogden, pers. obs.). No major habitat changes or other factors that would adversely affect large numbers of non-breeding storks in these 3 states are known to us. We therefore consider that the stork decline has been caused by one or more of the following factors: (1) reduction in the number of available nesting sites, (2) lack of protection at nesting sites, and/or (3) loss of an adequate food base during the nesting season.

Data in this paper show no positive correlation between numbers of colony sites and stability of regional nesting groups of Wood Storks. Statewide, the number of colonies was nearly the same during the 2 series of surveys: 17 in 1959–1960 and 19 in 1975–1976. In Southwest Florida, where stork numbers have declined sharply, the number of nesting sites has dropped only from 6 to 5. The drop in number of colonies, however, is unrelated to loss of nesting sites. The small colonies at Deep Lake and Rocky Lake likely were satellite colonies of Corkscrew, and although unchanged, have been abandoned only because the number of storks using Corkscrew has dwindled. Stork nesting at Madeira began the year after a major 1960 hurricane killed many trees at the nearby Cuthbert colony, although vegetation at the latter site has since recovered. In Central-North Florida, neither the geographical distribution nor total number of colonies greatly changed between the 2 series of surveys. Considerable shifting about by storks did occur, however, with only 3 of 11 sites active during both surveys. The fact that the percentage of birds nesting in impoundments and on mangrove islands dramatically increased suggests that although storks in this region may not yet be short of nesting sites, undisturbed cypress swamps that traditionally have been favored habitat are now in short supply.

Our impression of why cypress swamps in central Florida are now less frequently used by storks is based on observation and speculation. Lowered surface water levels due to drainage and numerous water management schemes have resulted in cypress swamps being dry more often in recent years than earlier, during the natural spring dry season when stork colonies form. Since storks in Florida characteristically nest in woody vegetation over water, or on islands surrounded by open water, fewer suitable cypress nesting sites have been available in recent years due to the dryness. During our surveys each year prior to the summer rainy season, we have seen many dry cypress swamps that appeared otherwise

suitable for nesting storks, including former or occasional colony sites at Croom, Lacoochee, Reedy Creek, Charlie Creek and Barley Barber Cypress.

The second suggested cause of the stork's decline, lack of protection from human disturbance at existing colonies, is not supported when colony histories are compared with colony protection. The largest Florida stork colonies at Corkscrew and in Everglades National Park have been among the best protected; these are the major colonies in the Southwest Florida region where storks have shown dramatic decline.

No clear relationship between colony security and population trends is evident in the Central-North Florida region. Two of the 3 colonies active during both series of surveys were insecure sites, while the 8 colonies that became inactive between surveys included 3 secure and 5 insecure sites. Two of the inactive, secure colonies were in surface phosphate impoundments (Tenoroc and Panther Point), and were lost due to shifting mining operations (that also create new colony impoundments). The 5 inactive, insecure colonies were all in natural cypress swamps and probably were abandoned because they became too dry, as described above, rather than because of human disturbance.

The third suggested factor, that storks have declined due to loss of an adequate food base, is supported by strong circumstantial evidence. Wood Storks feed primarily in freshwater sites, and use a grope-feeding technique that requires both high densities of fish and certain sizes of fish (Kahl 1964, Ogden et al. 1976). Storks also are larger than other Florida ciconiiforms and have higher food requirements in order to achieve successful nesting (shown in comparison to the White Ibis [*Eudocimus albus*] by Kushlan 1977). Therefore, any reduction in the food base or availability of fish in Florida wetlands will adversely affect storks sooner or more severely than other waders. Unfortunately, quantitative data on freshwater fish numbers in Florida wetlands prior to the 1960s are lacking, so we cannot demonstrate long-term quantitative changes in fish numbers or availability in Florida's freshwater ecosystems. Related studies and observations (cited below), however, strongly suggest that storks have become stressed by food shortages, both due to loss of feeding habitat and to adverse changes in fish biomass or availability in remaining wetlands.

Assuming fish numbers are dependent upon area of wetland habitats, then important food resources have been reduced, at least in south Florida, because a considerable portion of the freshwater wetland habitats have been eliminated during the twentieth century. Browder et al. (1976) categorized different wetland types south from the Lake Okeechobee system, and showed change in distribution and total acreage of each between 1900 and 1973. We combined 5 of these categories of freshwater habitats that

TABLE 4
NESTING SUCCESS AT WOOD STORK COLONIES WITH KNOWN OUTCOMES, 1971–1976[1]

Colony location	1971	1972	1973	1974	1975	1976
Central-North region						
Craven Hammock						F
Black Hammock			S			
Dee Dot	S	S	S	S	S	S
Cabbage Swamp						S
River Styx	S				F	
Lake Yale				S	S	
Turnbull						F
Moore Creek			S	F	S	S
Grant			S			
Pelican Island	S	S	S	S	S	S
Croom	F				S	
Reedy Creek	F					
Mulberry						S
El Clair	S		S	F		S
St. Johns Drainage	F			F		
Barley Barber	S	S		F		
Southwest region						
Corkscrew	S	F	F	S	S	S
Lane River			F	S	S	F
East River	F	F	F	S	S	F
Cuthbert	F	F	F			
Madeira	F	F	F	S	F	F

[1] S = success, F = failure.

are most important as feeding sites for storks (cypress domes and strands, wet prairies, scrub cypress, freshwater marshes and sloughs, and sawgrass marshes), and determined that the acreage of these 5 has been reduced by 35% since 1900. Thus, storks feeding in south Florida lack the number of feeding site options they once had.

Perhaps a more serious problem for storks than loss of feeding habitats are changes that must have occurred in remaining wetlands. Tracts of freshwater marshes and swamps remain throughout peninsular Florida, which on the basis of area alone appear to be capable of supporting greater numbers of storks than at present. Most are either impounded, partially drained or otherwise altered, and we suggest that these managed wetlands fail to maintain an adequate food base for Wood Storks, either by not producing enough fish or by not concentrating the fish in proper depths of water at the proper season. Supporting field data for this contention is at best tenuous. Allen (1958) discussed the effects of reduced production of

fish in an altered wetland, related to declining wading bird populations, when he reported his impressions of reduced fish abundance in the Everglades between the 1930s and 1950s. Ogden (1978) summarized recent population trends by colonial ciconiiforms on the Atlantic and Gulf coastal plains, and showed that most species or populations have been stable or increasing since the 1950s, except in some freshwater regions. The most serious declines occurred in the interior of Florida and involved several species with diverse food habits and feeding techniques, such as Snowy Egrets (*Egretta thula*), Little Blue Herons (*Hydranassa caerulea*), White Ibis and Wood Storks. Our assumption is that most remaining freshwater habitats have become less productive, a trend that adversely affects both density and biomass of a broad range of wading bird prey species.

Our subjective observations support the conclusion that altered freshwater wetlands in Florida are less productive, at least for the sizes of fish taken by storks. In the Everglades, storks no longer feed at peripheral wetland sites where they once were frequently reported (E. Winte, C. Brookfield, pers. comm.), a clue that shortened hydroperiods in this heavily managed system have adversely altered fish production or growth rates.

Stork nesting in the Central-North region apparently remained stable between 1960 and 1976 because of a higher frequency of nesting success in these colonies than in south Florida. Thirty-eight monitored nesting attempts at 16 different Central-North colonies between 1971 and 1976 (Table 4) resulted in 28 successful nestings (74%). We defined a successful nesting as one in which the number of fledged young equalled or exceeded the number of pairs of adults in the colony. In the Southwest Florida region, 25 nesting attempts at 5 colonies between 1971 and 1976 resulted in only 9 successful nestings (36%: pers. obs., J. Hansen, W. Robertson, J. Ogden).

Data on distribution and abundance of stork food are not sufficient to explain the higher rate of colony success in the Central-North region. It is interesting, however, that all south Florida colonies failed in 2 of the 6 years between 1971 and 1976, whereas some Central-North colonies were successful each year. The south Florida colonies are more geographically clumped and often show similar rainfall and water level patterns, and it is not surprising that adverse nesting conditions influence all colonies during the same year. The Central-North Florida region is geographically larger, and stork colonies are associated with many, widely separated wetland systems. The probability that conditions for successful nesting would be lacking throughout this region during any year is apparently low. So it appears that stability in the Central-North region is at least in part due to the geographical spread in colonies.

SUMMARY

Surveys of the resident population of Wood Storks in the southwestern United States showed that numbers of breeding adults declined 41% between 1960 and 1975. The decline has been sharp in the large south Florida colonies, while the number of birds breeding in a scatter of smaller colonies between central Florida and southeastern Georgia has remained stable or slightly increased. Reasons for the decline are discussed, including loss of colony sites, lack of protection at colonies, and loss of an adequate food base. We conclude, largely through circumstantial evidence, that the single important factor responsible for the stork decline has been a loss of feeding habitats coupled with a reduction in fish biomass or food availability in remaining wetlands.

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