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RECENT POPULATION TREND OF THE SNAIL KITE IN FLORIDA AND ITS RELATIONSHIP TO WATER LEVELS

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The Florida population of the Snail Kite (*Rostrhamus sociabilis plumbeus*) has declined over the years because of drainage projects that destroyed much of its original freshwater marsh habitat and modified the wetlands that remain (Howell 1932, Sprunt 1945, 1950, Stieglitz and Thompson 1967, Sykes 1979). In Florida the Snail Kite depends upon the apple snail (*Pomacea paludosa*) for food (Howell 1932, Bent 1937, Cottam and Knappen 1939). This mollusk is abundant and available to the kite only when the marsh is flooded. Snails are not uniformly distributed in a marsh. Areas where they are abundant have usually been flooded continuously for several years (Sykes 1979).

Kite population estimates for Florida before 1969 are incomplete (Sykes 1979), but an apparent steady decline started after large drainage projects were completed in the Everglades region in the early 1900's. Other drainage projects followed intermittently to the 1960's and the downward trend continued (Sprunt 1945, 1954, Stieglitz and Thompson 1967). The kite apparently reached its lowest population level in Florida during the 1950–1965 period when there were perhaps fewer than 40 individuals remaining.

A standardized annual census of the kite population has been conducted in Florida since 1969. Results of the 1969–1978 censuses were reported by Sykes (1979). This paper updates the census results through 1980, presents the basic reason for the observed population changes, and makes some management recommendations.

METHODS

The census methods used in 1979 and 1980 were those of Sykes (1979). Three population categories were used: (1) gray birds—males 3 years and older; (2) brown birds—all females and first- and second-year males; and (3) unknown—individuals too poorly seen to assign to either gray or brown groups. The principal areas covered are shown in Fig. 1. These areas comprised approximately 95 to 98% of the kites' universe for the period of study. From 1969 through 1980, 592 h were spent censusing ($\bar{x}$ = 49 h per annual census). The differences in effort from year to year were small and did not affect census results. The census totals are the minimum number of individuals observed. My part in the annual censusing was completed with the 1980 census. From 1981 onward the censusing of Snail Kites in Florida became the responsibility of the Florida Game and Fresh Water Fish Commission.

Daily readings of established U.S. Army Corps of Engineers water gauges provided water level data. Available water gauge readings and ground-surface elevations, originally given in feet above mean sea level

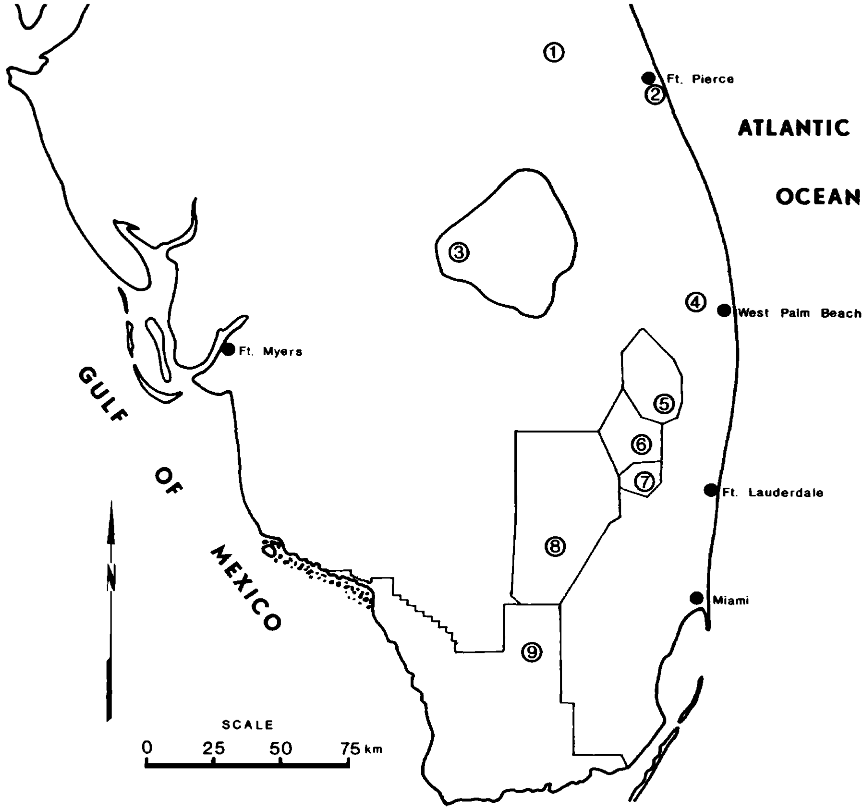

FIGURE 1. The principal existing Snail Kite habitats censused in Florida. 1. Headwaters of the St. Johns River, Indian River and St. Lucie counties (includes the St. Johns, Cloud Lake, Strazzulla, Bel Air, and Indrio reservoirs). 2. The Savannas, St. Lucie Co. (that portion north of State Road 712). 3. Lake Okeechobee, Glades and Hendry cos. (west side of the lake from Indian Prairie Canal south to Moore Haven and Clewiston). 4. Loxahatchee Slough, Palm Beach Co. (that portion within the Lake Park Reservoir). 5. Loxahatchee National Wildlife Refuge, Palm Beach Co. (east, south, and southwest sectors). 6. Conservation Area 2A (CA2A), Palm Beach and Broward cos. (eastern and southern halves). 7. Conservation Area 2B (CA2B), Broward Co. (eastern and southern edges). 8. Conservation Area 3A (CA3A), Broward and Dade cos. (all sectors south of Alligator Alley except the central portion of the area). 9. Everglades National Park, Dade and Monroe cos. (northern and eastern edges, and Shark and Taylor sloughs).

(msl), were converted to the nearest whole centimeter. Since the most critical period for the kite in Florida is the end of the annual dry season in late spring, I used the lowest water level readings between late April and early June as the best indication of habitat quality.

The daily water level readings at Lake Okeechobee were the mean

TABLE 1. Annual Snail Kite census results for Florida, 1969–1980.

Year	Population categories						Ratio brown to gray birds	Total number of kites
	Gray birds[1]		Brown birds[2]		Unknown			
	Number	%[3]	Number	%	Number	%		
1969	20	20	76	78	2	2	3.8:1	98
1970	21	18	87	72	12	10	4.1:1	120
1971	23	32	49	68	0	0	2.1:1	72
1972	23	43	36	55	6	9	1.6:1	65
1973	41	47	52	55	2	2	1.3:1	95
1974	38	43	33	41	10	12	0.9:1	81
1975	47	37	52	47	11	10	1.1:1	110
1976	52	38	76	53	14	10	1.5:1	142
1977	58	25	91	60	3	2	1.6:1	152
1978	66	15	187	70	14	5	2.8:1	267
1979	63	15	343	79	25	6	5.4:1	431
1980	101	15	486	75	63	10	4.8:1	651
Mean/year	46.1	29	130.7	63	13.5	7	2.6:1	190
Standard Error	6.64	3.5	39.2	3.6	4.7	0.8	0.4	49

[1] Adult and subadult males.
[2] Females and immature males.
[3] Percent of total count.

of 13 gauges around the perimeter of the lake (U.S. Army Corps of Engineers 1968–1980). The depth of flooding in the marsh was determined by subtracting the mean ground-surface elevation of 3.5 m (derived from field observations in combination with data of Pesnell and Brown [1977]) from the water gauge readings. The depth of flooding in Conservation Area 3A (CA3A) was similarly derived using a 3-gauge mean for water levels and water gauge No. 3–28 in the south-central part of the area with a ground-surface elevation of 2.1 m as the mean elevation datum. The values for water depths in the marshes are subject to error for the following reasons: (1) few gauges (13 at Lake Okeechobee, 3 in CA3A) in the large areas studied; (2) location of the gauges in relation to areas used by kites; (3) lack of accurate ground-surface elevations in most parts of the marshes; and (4) problem of wind-tide effects at Lake Okeechobee. Because of the restraints of time, manpower, and funding, more precise water levels were not available.

The relations between kite populations and lowest water depths were examined using the Pearson correlation coefficient. I analyzed this relation by area (Lake Okeechobee, CA3A) for the total kite population, for gray birds, and for brown birds (1974–1980 only). Because the variance of kite populations tended to increase with the mean, I applied a logarithmic (base 10) transformation to the population values; the transformed data yielded stronger statistical relations than did the raw data.

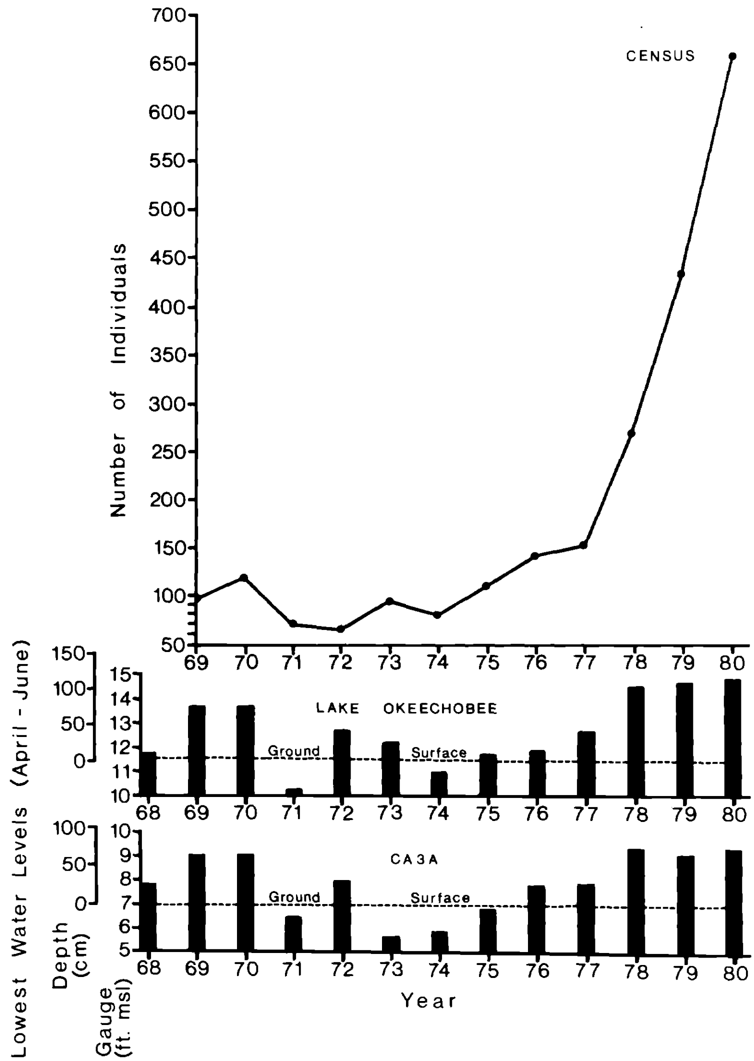

FIGURE 2. Annual Snail Kite censuses compared to the lowest recorded water levels and the depths of flooding in the marshes at the end of the dry seasons for Lake Okeechobee and CA3A. The outer scale for water levels is the depth of flooding in the marsh in centimeters and the inner scale is the actual water gauge readings as standardized throughout South Florida in feet above mean sea level.

RESULTS

The number of kites on the annual censuses ranged from a low of 65 in 1972 to a high of 651 in 1980 (Table 1, Fig. 2). From 1974 through 1980 the population has shown a highly significant increase of 803%

TABLE 2. The number of Snail Kites recorded on annual censuses in principal existing habitats.

Locality	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	% of years recorded
Headwaters													
St. Johns River	0	0	10[1]	1[2]	0	0	0	0	0	0	0	0	17
The Savannas	0	0	0	0	0	0	0	0	2	3	0	1	25
Lake Okeechobee	0	1	11	11	25	24	34	51	48	46	114	214	92
Loxahatchee Slough	0	0	0	0	0	0	1	2	0	0	0	0	17
Loxahatchee N.W.R.	9	31	6	0	7	7	7	0	0	0	0	0	50
CA2A	80	3	0	0	0	2	6	5	2	0	0	1	58
CA2B	0	20	0	0	0	0	0	0	0	6	41	115	33
CA3A	0	51	39	53	63	48	62	84	100	212	273	305	92
Everglades Natl. Park	9	13	6	0	0	0	0	0	0	0	3	15	42
Other[3]	0	0[4]	0	0	0	0	0	0	0	0	0	1[5]	17

[1] St. Johns Reservoir.
[2] Cloud Lake Reservoir.
[3] Includes Lake Kissimmee (Osceola and Polk cos.), Lake Hicpochee (Glades Co.), western part of CA3B, East and Southeast Everglades (Dade Co.).
[4] West side CA3B.
[5] NE shore of Lake Kissimmee (Osceola Co.).

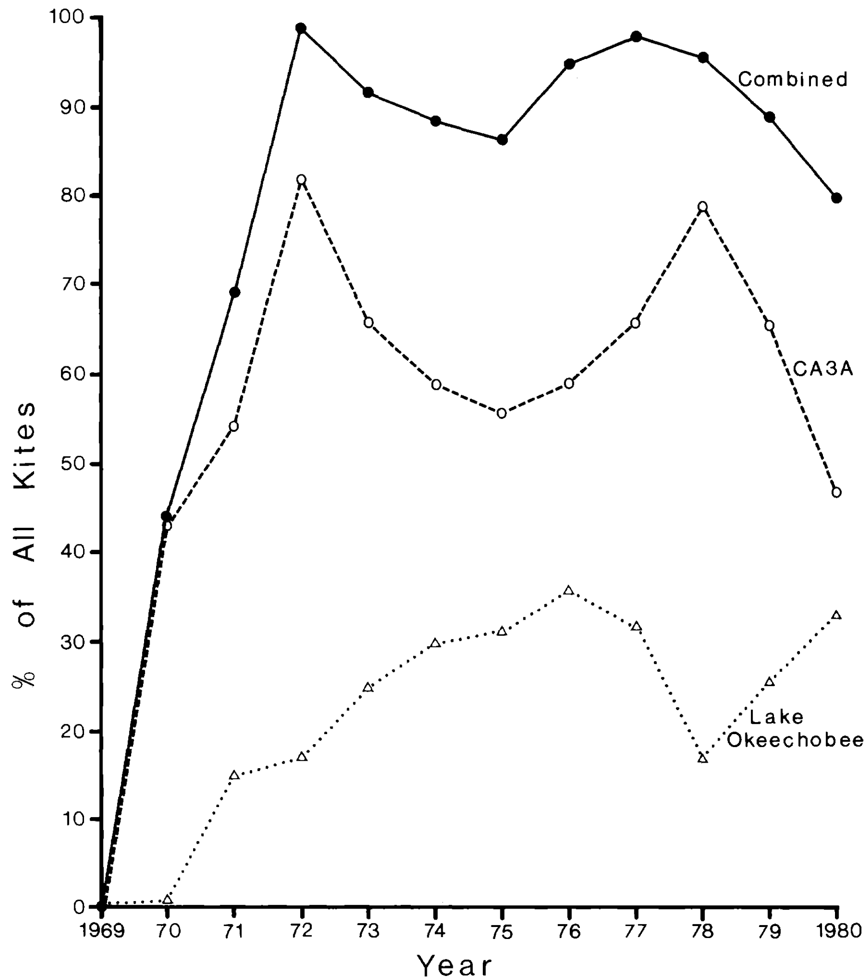

FIGURE 3. Percent of Snail Kites recorded on annual censuses in two principal habitats.

($r = .981$, $P < .001$). Sightings of gray birds increased steadily from 38 to 101 (265%; $r = .946$, $P < .001$) and brown birds from 33 to 486 (1473%; $r = .991$, $P < .001$). The numbers of brown birds were highly correlated ($r = .875$, $P < .001$) with the census totals, increasing 29% from 1979 to 1980. The ratio of brown to gray kites is presented in Table 1. It increased from 1969 to 1971, and from 1974 to 1979, with the low in 1974.

Throughout the 12-year study, Lake Okeechobee and CA3A supported the largest number of individuals and had the most consistent use (Table 2, Fig. 3), while 10 other areas (Table 2) had only sporadic

TABLE 3. Lowest depths of flooding at the end of the dry season for Lake Okeechobee and CA3A.

Year	Depths of flooding (cm)	
	Lake Okeechobee[1]	CA3A[2]
1968	+6	+27
1969	+67	+64
1970	+67	+64
1971	−37[3]	−15
1972	+37	+31
1973	+21	−43
1974	−15	−31
1975	+6	−3
1976	+12	+24
1977	+37	+27
1978	+91	+70
1979	+98	+61
1980	+104	+70
Mean	+40.7	+26.6
Standard Error	12.6	11.4

[1] Mean ground surface elevation in marsh, 3.5 m (11.5 feet) msl.
[2] Ground surface elevation in marsh at water gauge No. 3-28 used as a mean, 2.1 m (7.0 feet) msl.
[3] Numbers with negative signs represent the distances the flooding depths were below the mean ground surface elevations.

use. The overall trends at Lake Okeechobee and CA3A were indicative of the population as a whole.

The number of evening kite roosts in CA3A increased from 8 in 1979 to 16 in 1980, and in the latter year the roosts were more widespread. At least 4 additional roost sites were suspected in 1980, but were not located. Most of the new roosts included fewer than 3 kites. The number of roosts at Lake Okeechobee increased from 5 to 6 during the same period. At least one other roost probably existed on the lake in 1980 but was not found. The number of roosts in Conservation Area 2B (CA2B) increased from 1 in 1979 to 2 in 1980.

The mean lowest depth of flooding was 40.7 cm at Lake Okeechobee and 26.6 cm in CA3A (Table 3). During the 1971 and 1974 droughts, the lake marsh went dry when water levels fell below the mean ground-surface elevation (negative numbers). Only during the 1971 drought did the entire marsh in CA3A go dry. The water depths in that area in 1973–75 were low for relatively short periods. The appearance that 1973 and 1974 were drier than 1971 (larger negative numbers, Table 3), when they actually were not, is an artifact of using a single value for the ground elevation for such a large area and also possibly, gauges measuring local conditions where there were no kites.

Lowest water level readings and corresponding flooding depths at the end of the dry season for the two principal habitats are shown in relation to the kite census totals in Fig. 2. The population of kites shows a strong correlation with water depth at Lake Okeechobee ($r = .777$, $P < .001$) and CA3A ($r = .625$, $P < .02$).

DISCUSSION

Censuses on consecutive days taken in 1976 had an error of 9.4% (Sykes 1979). Assuming a similar precision in 1980, the observed 651 kites gives a population estimate of around 700 individuals. This is perhaps the largest number of Snail Kites in Florida since the initial major drainage projects were completed between 1910–1915. The 12-year ratio of brown to gray kites was 2.6:1, and the maximum for one year (1979) was 5.4:1. The increase in the ratios in the 1969–1970 and 1978–1980 periods is attributed to recruitment from reproduction. The decreases from 1971 through 1975 are the result of lack of recruitment in 1971 and low recruitment in 1972 and 1974. The time lag because of the 3 years required for immature males to acquire the gray plumage is also reflected in the ratios. The greater ratios indicate a large immature component within a rapidly expanding population.

Lake Okeechobee and CA3A, in addition to being the principal areas used by kites in fall and winter (Fig. 3), have also been the main nesting sites in recent years (Sykes 1979). Ten other areas had sporadic use (Table 2), indicating less frequent occurrence of conditions favorable to the birds. Obviously, Lake Okeechobee and CA3A are essential to the future of the kite in Florida. From 1969 through 1980 these two areas had a mean of 25 and 56% respectively of the total kites recorded on the censuses.

Favorable conditions for kites in Florida are keyed to the depth and duration of marsh flooding. Water levels can fluctuate as long as the entire marsh does not become completely dry. The dry conditions associated with the 1971 drought and the low water levels in CA3A in 1973 resulted in a decrease in the kite population (Fig. 2). The full effect of dry conditions may thus not be evident until the next year. This seemed to be the case in both the 1971–1972 and the 1973–1974 periods.

High water conditions from 1975 through 1980 were the result of normal rainfall in combination with manipulation of water levels by man for water storage, recharge of the aquifers supplying water to the cities of the southeast coast, and flood control. The water levels maintained in the two principal habitats were managed with no thought as to the needs of the kite, but by coincidence improved conditions for the population which increased steadily and rapidly under high water conditions after 1974. So long as such conditions prevail, we can expect the kite population in Florida to increase and reoccupy more of its former habitat. The distribution and establishment of new roost sites is also an indication of rapid population increase and movement by the birds. The nomadic tendency of the species in Florida (Sykes 1979) enables the birds to quickly reoccupy areas once favorable conditions return. The population will predictably decrease during severe droughts or dry conditions created as a result of water level manipulation.

Management of water levels at Lake Okeechobee within a range of 4–5 m (13–16.5 feet) msl should maintain adequate habitat for the kite, but this is only possible when enough water is available. In the long term the best method of managing water levels in the CA3A sector of the Everglades ecosystem would be to restore sheet flow across the marsh. Such conditions would provide more uniform flooding across the entire marsh, water levels would rise and fall more gradually, the area would remain wetter for longer periods in dry years, and the effects of droughts would be greatly diminished or otherwise lessened. The Kissimmee Valley, Lake Okeechobee, and the Everglades are hydrologically one large system with the water movement starting in a chain of lakes near Orlando and flowing southward to Florida Bay in the southern part of the Everglades National Park (Parker 1974). The system evolved and was self-perpetuating under sheet flow conditions and was functional until the early 1900's when drainage projects destroyed this essential element. All natural components of CA3A would benefit from restored sheet flow, including the Snail Kite. While the original Everglades was not a stable environment, and drought conditions occurred periodically, the impact of man has made dry conditions more severe and prolonged in drought years.

The Snail Kite has characteristics of a typical boom-and-bust species subject to radical, irregular fluctuations in relation to its food supply. For example, it is nomadic, has a very high intrinsic rate of increase, and has flexible breeding schedules. Undoubtedly, kites will increase in direct proportion to areas of continuously flooded marsh with large apple snail populations. The kite appears to be strongly adapted to take maximum advantage of favorable circumstances in a very uncertain environment. Annual census results from 1969 through 1980 revealed that the upward or downward trend of the Snail Kite population in Florida can be predicted based upon water level conditions. Management of selected areas would in years of drought reduce the decline by providing small scattered blocks of suitable habitat to carry the kites through these critical periods.

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