MONITORING OF WADING BIRD COLONY LOCATION, SIZE, TIMING AND WOOD STORK AND ROSEATE SPOONBILL NESTING SUCCESS.

Everglades Monitoring And Assessment Plan Activity
3.1.3.13 and 3.1.3.14

Final Comprehensive Summary Report
For Lake Okeechobee, the WCAs of the Everglades, Mainland Everglades National Park and Florida Bay.

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CHAPTER I. NESTING BY WADING BIRDS IN THE CENTRAL EVERGLADES, AND MONITORING OF WOOD STORK REPRODUCTION

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NESTING BY WADING BIRDS IN THE CENTRAL EVERGLADES, AND MONITORING OF WOOD STORK REPRODUCTION IN 2004.

Executive Summary

We found 46,177 nests of all wading bird species in the WCAs of the Everglades in 2004, which follows large increases in 2001 – 2003. This general increase in nesting numbers was most pronounced for White Ibises, but nesting populations of nearly all species monitored have increased in the last several years. The large increases appear to have started in 1999. Since 1999, we have seen 6 of the seven record nesting years in the Everglades of the past 19 (the only exception is 1992), and the average number of nests in 1999 – 2004 (38,734) is over three times as large as the average of 1986 – 1998. The capacity of the northern and central Everglades to support large nesting aggregations and the production of large numbers of offspring appears to have increased in a fairly dramatic and consistent fashion.

Nest success also appears to have been generally good in the past four years, with relatively few abandonments of entire colonies. These years have not been without poor nest success (2003 for most species, 2004 for storks), and in one year (2002) nesting would have been catastrophically bad were it not for an unusual extension of the dry season into July. While it is not clear that reproductive success was measurably better on a per nest basis during 2001 – 2004, the very large numbers of nests meant that large numbers of chicks were produced. This period therefore appears to have made a large contribution to the populations of most species, and may have established a demographically important element.

During the period since 1999, ibises have increased in proportional dominance of numbers of wading bird nests (X = 51.5% 1999 – 2004, X = 31% 1986 – 1998), and the increase in ibises explains much of the increase in total numbers of nesting birds. We saw no evidence of earlier nesting by Wood Storks during this period, which has been stated as one of the desirable outcomes of Everglades restoration. Similarly, we saw no convincing evidence of an increased tendency to nest in the coastal zone (also a targeted

outcome of restoration), although several important and novel colonies have been established in the mangrove/freshwater interface of Everglades National Park during the study period.

We report on several new methods designed to increase accuracy of counts of nests, particularly in large colonies – these include use of aerial photography, comparison of aerial and ground counts, and the quantification of underestimation due to asynchronous nesting and nest failure. Counts from aerial photographs of ibises, for example, may underestimate nests by large factors (up to 88 times, and more often three times), and the degree of error appears to vary considerably even in different parts of the same colony.

Wood Storks nested in 2004 at a number of colonies in Everglades National Park (Paurotis Pond, Tamiami West) and WCA 3 (3B Mud East, Crossover). Mayfield nest success in 2004 was 46.49%. First year survival in the nestlings also varied considerably in the last several years, with 41.4%, 11.6% and 41.6% of nestlings surviving their first year in 2002, 2003, and 2004 respectively. Second year survival for the 2002 cohort was much higher than first year – 83.3%; second year survival from the 2003 cohort was meaningless to calculate because only a single bird was living.

Introduction and background

The numbers of breeding pairs of wading birds in the Everglades, and their reproductive success measures have been used for some time to reflect hydrological and biotic conditions in the Everglades, and there is compelling evidence that various aspects of wading bird reproduction and foraging ecology can be mechanistically linked with various aspects of the ecology of wetlands, at a variety of scales (Frederick and Ogden 2003, Frederick 2002). While some of these linkages are simple enough to be revealed by short-term studies, a full understanding of the interplay of many variables (eg, hydrology, weather, vegetation, prey and fire cycles) is only possible through the use of long term records. For example, an 80-year record of nesting and hydrology was required to discover that exceptionally large and significant breeding events were almost always preceded by infrequent, severe droughts (Frederick and Ogden 2001).

Thus the monitoring of wading birds has been a powerful tool in unraveling the ecology of the birds and the ecosystem, and ongoing monitoring is likely to pay off in further understanding and management applications (Frederick and Ogden 2003). First, the long-term nature of the record of the existing nesting record is a powerful context for comparison of any future years. Second, the long term record becomes more powerful with each passing year, particularly for the analysis of the importance of rare combinations of events. Third, a key prediction of the restoration program is that hydrological restoration will result in increased populations of wading birds, earlier nesting for some species, and increased nesting success for some species. While this is a reasonable set of predictions given our understanding of these relationships, there is still a lot of uncertainty in the accuracy (in both space and time) of the prediction. This is because wading bird nesting numbers are probably influenced by alternative nesting opportunities outside the Everglades, and because the influence of contaminants may confound the predicted relationship between hydropattern and nesting. Wading bird nesting is therefore a key criterion of restoration, and aspects of their reproductive ecology (energetics, timing, productivity) have the potential for fine-tuning the way that the hydrology of the Everglades is managed, as well as the relationship between hydrology and nesting. For these reasons, continued monitoring of the Everglades breeding populations is likely to provide crucial information, both for evaluating the progress of restoration, and for refining our understanding of the underlying ecological relationships between the aquatic ecology of the ecosytem and the birds.

The Wood Stork (*Mycteria americana*) is the only stork (Ciconidae) breeding in the United States, and is a federally endangered species. Wood Storks have special relevance for the restoration of the south Florida ecosystem (encompassing the Kissimmee basin, Lake Okeechobee, the Everglades, Big Cypress, wetlands of southwest Florida, and Florida Bay). Historically, this area was the core reproductive habitat for the species, to the extent that over 75% of the U.S. population was thought to breed in this area (Coulter et al. 1999). The breeding population in the Everglades has declined by over 80% since the 1930s and by at least 50% since the 1960s. In addition, storks have shifted the timing of nesting in the Everglades from November/December initiations, to February/March initiations (Ogden 1994). This shift in timing has meant that storks are usually rearing young during the onset of summer rains, when surface water levels rise, prey disperse, and young storks typically starve. In addition, storks have shown marked shifts in the location of nesting, having moved gradually from almost entirely coastal nesting in the Everglades, to inland nesting, as a result of gross dewatering of the coastal regions of the Everglades (Ogden 1994). Because of their foraging habit and population response to habitat degradation, storks are thought to be one of the best indicators of hydrological restoration of ecosystem function in the Everglades.

Although the planning for restoration of the South Florida Ecosystem is well underway, considerable uncertainties remain about the reproductive responses of storks, including how soon storks might respond to a restored ecosystem, where and when they will nest, the relative importance of wetland areas outside the Everglades, and how the population will respond to specific levels of reproductive productivity. Although there is a considerable amount known about the reproductive ecology of storks, there is very little information about the survival or movement patterns of adult and juvenile storks. This has meant that the relative influence of areas outside the Everglades on stork populations is largely unknown, and this lack of understanding could well confound our interpretation of stork responses to restoration. For example, if stork populations respond negatively to restoration, we could (at present) not distinguish between inappropriate restoration as a cause, or appropriate restoration coupled with degenerating habitat quality outside the ecosystem. As well, the near-complete lack of information on stork survival has meant that it is impossible to even crudely model stork demographic responses.

Weather and water conditions during 2004

Rainfall: The period of study was preceded (1994 – 1997) by an extended period of higher than normal rainfall, and high water stages. During January 1998 through July 2001, the rainfall patterns could be characterized neither as extreme drought nor as particularly wet. Figure 1.1 shows monthly rainfall totals during the period as deviations from long-term monthly averages. The degree to which rainfall was extreme is illustrated by one standard deviation in excess or deficit of the long-term mean. The only exception to this rule was June of 1998, which had nearly seven inches less rainfall during June than the long term average. The dry seasons of 2000 and 2001 were characterized by having below-average rainfall, though very few months were less than one standard deviation of monthly means.

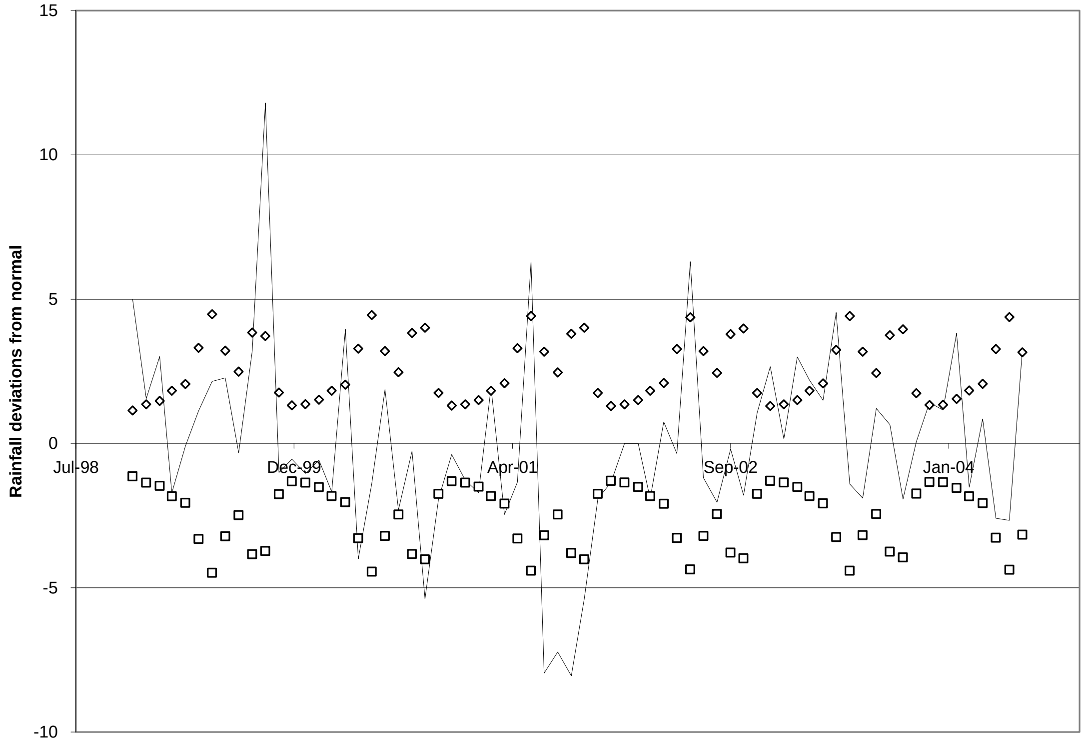

Figure 1.1. Monthly rainfall, 2000 – 2003 at Tamiami Trail Ranger Station. Recorded monthly totals (continuous line) are shown as deviations from the long term mean (=0 on the graph). Long term monthly maximums plus one standard error (diamonds) and mean monthly minimums minus one standard error (open squares) are shown for reference.

Mean monthly temperatures during the study period were generally higher than normal (Figure 1.2), with no severe freezes during the period. The only exception was during February of 2001, when a single very cold week occurred.

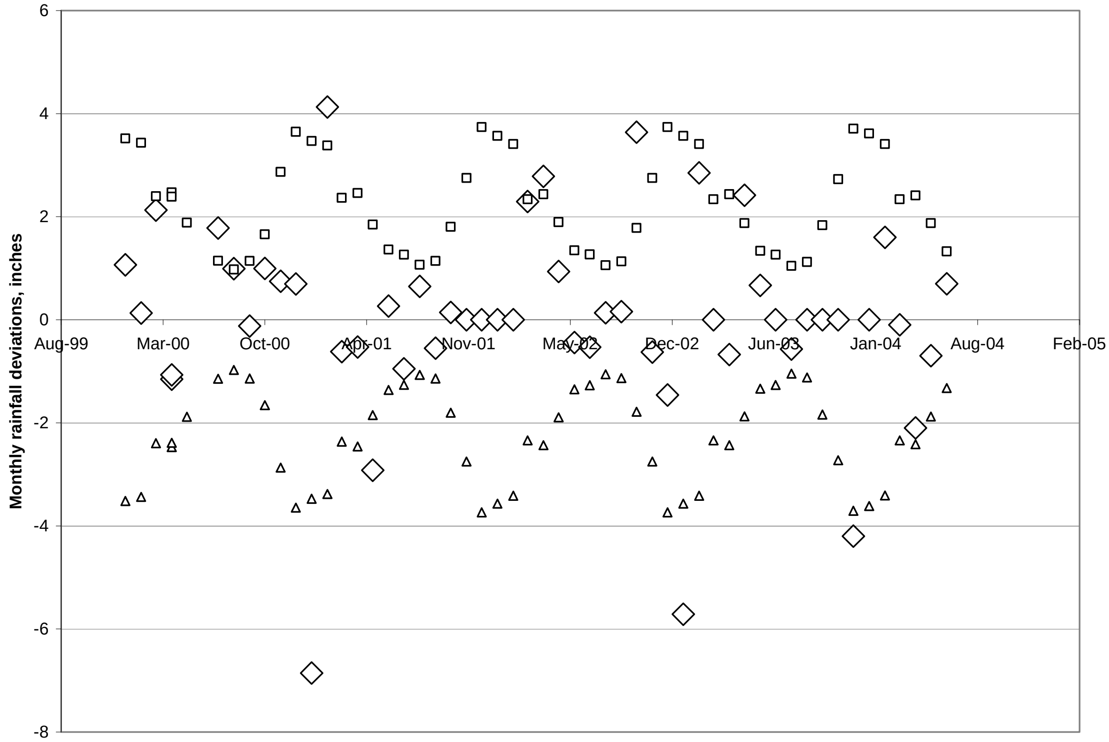

Figure 1.2. Monthly temperature deviations at the Tamiami Ranger Station in Everglades National Park, 2000 – 2004. Large diamonds indicate monthly deviations from long term mean (expressed as zero on the y axis). Long term mean monthly maximums plus one standard error (open squares) and monthly minimums minus one standard error (open triangles) are shown for reference.

Hydrology:

The period of study was preceded by a lengthy period of considerably higher stages than normal (1994 – 1997), during which wading bird nesting was comparatively depressed (depending on species). During the period prior to and during 2004 in WCA 1, stages remained consistently higher than normal, being between the average maximium for any month, and one standard deviation higher than the average monthly maximum (Figure 1.3). This trend is partially a result of intentional management for higher stages within Loxahatchee National Wildlife Refuge (NWR).

A series of short drying events followed by reversals began in October 2003, and continued throughout the fall. While spring drying rates were rapid in 2004, the most impressive thing about the season was the lack of rainfall in May and June. Effectively the drying season continued unabated through the second week of July.

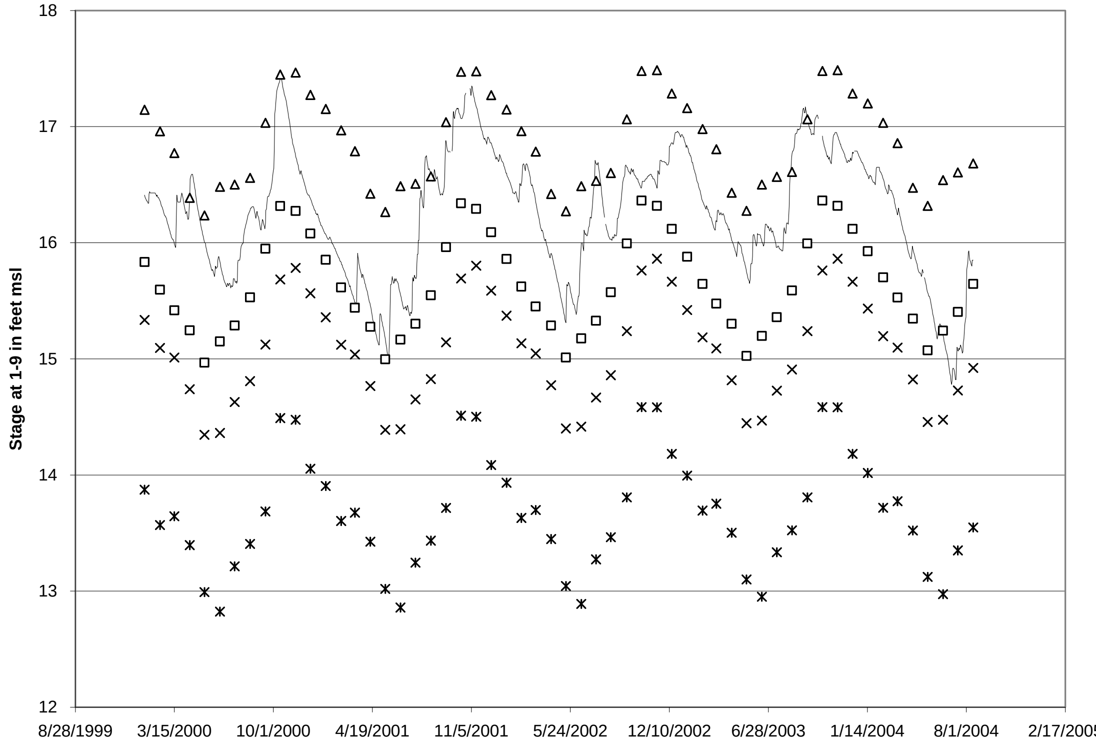

Figure 1.3. Stages at 1-9 gage in central Loxahatchee NWR, 2000 – 2004. Daily stage is shown as a solid line. Long term monthly mean maximums (squares), minimums (X's), maximums plus one standard error (triangles) and minimums minus one standard error (asterisks) are shown for reference.

Similar behavior was seen in WCA 3, with higher than normal stages throughout the study period (Figure 1.4). Apparently, in the WCAs, stages were high to normal in nearly every month of the study period, including the height of the dry season. In addition, many of the reversals seen in WCA 1 were smaller and apparently buffered by the larger size of WCA 3.

Drying in the winter of 2003/4 in WCA 3 began in October, and continued almost unabated until a reversal in February. As in WCA 1, the dry season did not really end until sometime in early July.

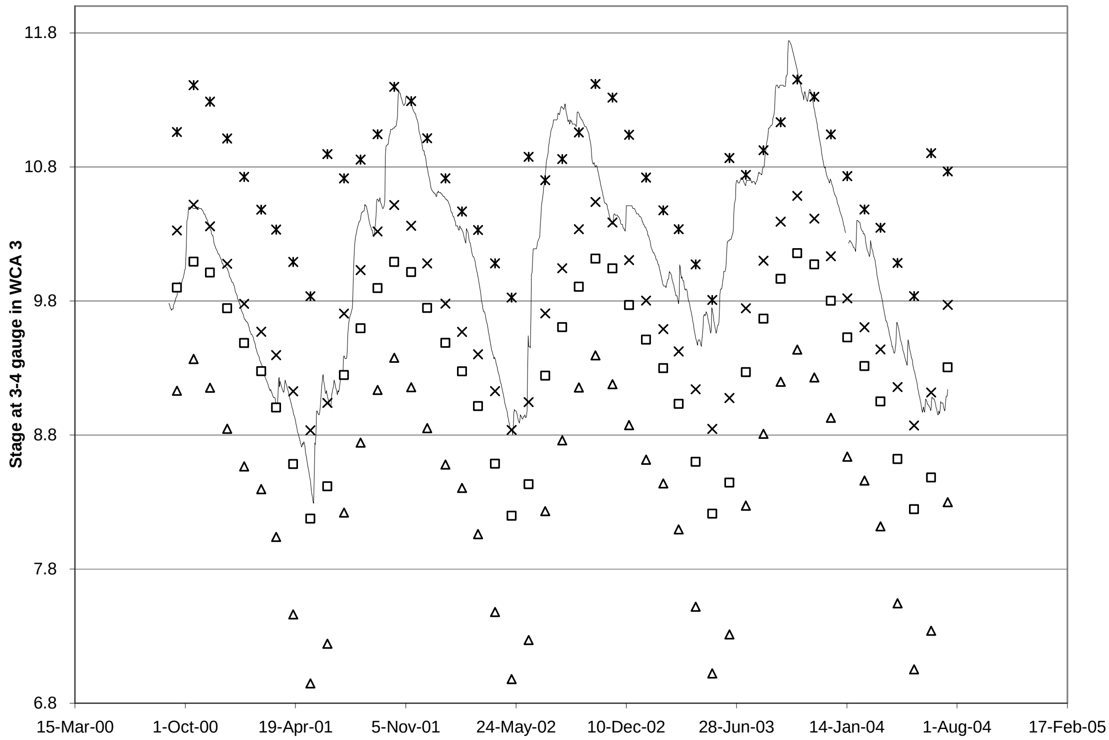

Figure 1.4. Stages at 3A-4 gage in central WCA 3A, 2000 – 2004. Daily stage is shown as a solid line. Long term monthly mean maximums (x's), minimums (squares), maximums plus one standard error (asterisks) and minimums minus one standard error (triangles) are shown for reference.

In WCA 2A, the pattern was much less consistent than in WCAs 1 and 3, with generally flashier water behavior (Figure 1.5). This is in keeping with WCA 2 being used heavily by water management to buffer changes in other management units. Unlike in WCAs 1 and 3, water levels were in the middle of the historic range in WCA 2 for most of the period, with wide swings to both the upper and lower bounds of normal. Most of the same drying trends and reversals are evident in WCA 2A as in WCAs 1 and 3, but generally more extreme in most cases. This is in keeping with the smaller size of WCA 2A and its use as a transfer area.

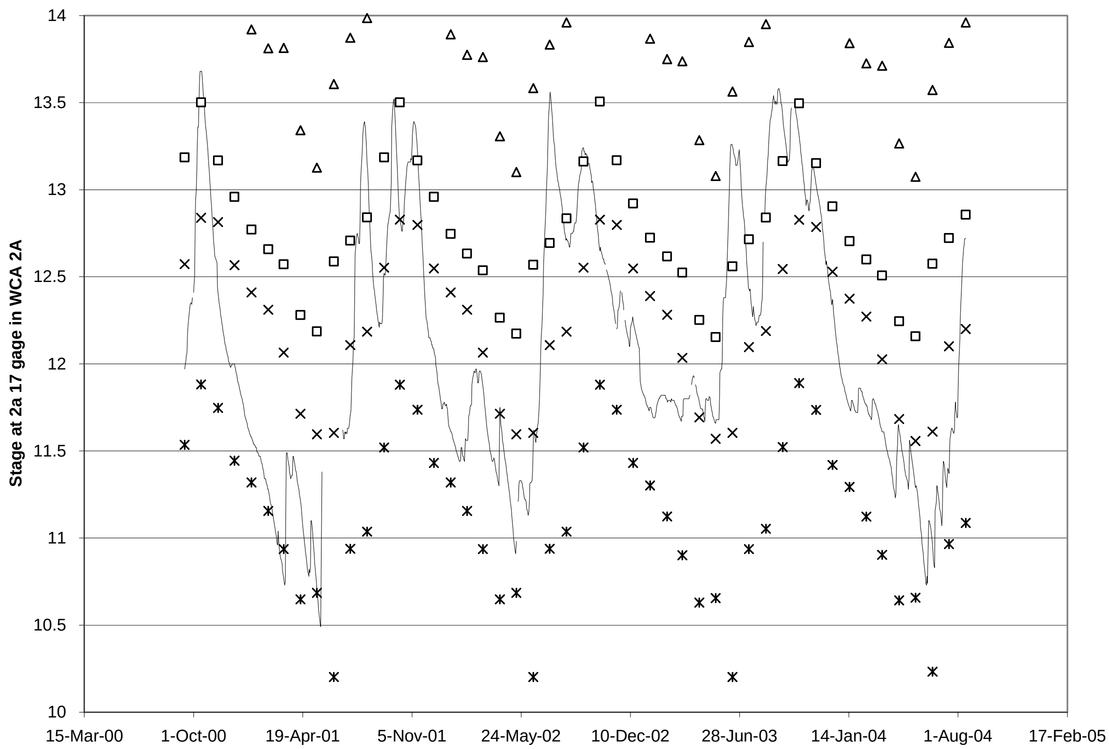

Figure 1.5. Stages at 2A-17 gage in central WCA 2A, 2000 – 2004. Daily stage is shown as a solid line. Long term monthly mean maximums (squares), minimums (x's), maximums plus one standard error (triangles) and minimums minus one standard error (asterisks) are shown for reference.

In the past, the behavior and reproductive response of birds has been thought to be predicted in part by the rate at which surface water recedes during the dry season (Kushlan et al. 1975, Frederick and Collopy 1989), as a result of both drainage and evapotranspiration. The mechanism of influence on the birds is through the concentration of prey animals on the marsh surface by the action of decreasing depths. This has been expressed as an early season recession rate (difference between monthly highs of November and January) and a "late" recession rate (difference between monthly highs of January and March). Note that a "fast" recession rate would be a high positive number, signifying rapid recession (2 mm/d and above), and a "slow" rate could be represented by negative numbers (stage actually increased between the two months).

In 2003, early drying was negative in WCA 1, and practically stable water was observed in WCA 3 (Table 1.1). WCA 2, however, had a respectable drying rate, exceeding almost 70% of observations. Late drying rates were mediocre in WCA 3 and 2 and considerably faster in WCA 1. In 2004, early rates were fast in WCA 2 and 3, but mediocre in WCA 1. Late rates were fast in 2A, again slow in Loxahatchee and respectable in WCA 3.

Table 1.1. Water level recession rates (mm/d) in the Water Conservation Areas, with comparisons of the year in question with historical records at each station.
Note that negative values indicate rising water, positive values indicate falling water. Percent exceedance refers to the percent of years in the record in which the drying rate was less than that of the current year.

Year	Station	Early Dry*	Late Dry*	% Exceedance Early Drying Rate	% Exceedance Late Drying Rate	% Exceedance Both Early and Late Drying Rate
2004	3-4	5.18	2.19	90.2	53.7	53.7
2004	1-9	1.46	1.27	36.8	36.8	7.9
2004	2A 1-7	6.80	3.98	90.7	90.7	86.0
2003	3-4	0.400	1.524	22.5	37.5	20
2003	1-9	-3.690	2.573	2.7	62.2	0
2003	2A 1-7	3.146	1.559	69.0	50.0	33.3
2002	3-4	4.001	1.96	75.6	48.6	43.2
2002	1-9	9.26	1.54	97.5	47.5	45.0
2002	2A 1-7	3.27	0.723	80.6	22.2	16.7
2001	3-4	3.098	2.43	55.6	61.1	33.3
2001	1-9	4.347	1.16	91.4	28.6	22.9
2001	2A 1-7	6.246	2.32	92.3	94.9	89.7
2000	3-4	7.935	7.70	100	100	100
2000	1-9	4.54	na	94.1	na	Na
2000	2A 1-7	7.595	5.57	94.5	94.8	89.7
1999	3-4	2.13	3.83	41.7	91.7	38.9
1999	1-9	2.19	4.24	18	29	14
1999	2A 1-7	7.77	7.46	97.2	94.5	97.1
1998	3-4	-0.60	0.11	4.88	21.92	0.00
1998	1-9	1.48	-0.52	34.3	2.85	0
1998	2A 1-7	-4	-0.04	2.9	20	0
1997	3-4	2.63	1.419	57	42	36
1997	1-9	2.19	0.581	51.5	15.2	3.03
1997	2A 1-7	4.12	2.77	94.1	73.5	70.5
1996	3-4	6.99	5.68	100	100	100
1996	1-9	0.14	0.383	25.0	3.5	0.0
1996	2A 1-7	11.50	0.646	96.9	34.4	34.4
1995	3-4	-0.90	5.95	0.0	100.0	0.0
1995	1-9	0.97	0.21	32.1	10.7	3.6
1995	2A 1-7	0.55	3.50	28.1	87.5	29.0
1994	3-4	2.56	-1.08	58.6	6.9	3.6

1994	1-9	1.49	0.42	21.8	9.3	3.1
1994	2A 1-7	3.32	-4.67	90.0	3.3	3.3
1993	3-4	0.22	-0.40	10.0	10.0	3.3
1993	1-9	-0.33	3.91	14.8	7.8	0.0
1993	2A 1-7	-1.45	0.22	12.9	29.0	3.2
1992	3-4	2.29	2.63	24	38	14
1992	1-9	2.01	1.47	46	54	21
1992	2A 1-7	3.16	2.09	82.1	53.5	44.4

* Early drying rate is the difference in water level between the monthly high stage in November, and the monthly high stage in January, divided by the number of days in between the two measurements. Late drying rate is the same measure between the high in January and the high in March.

Methods

In all years of study, we performed two kinds of systematic surveys to document wading bird nesting in Water Conservation Areas 2 and 3 (and beginning in 2002, WCA 1) – aerial and ground surveys. These two kinds of surveys are complementary, and in the Everglades, neither does a good job alone (Frederick et al. 1996). The primary objective of both kinds of surveys is to systematically encounter and document nesting colonies. On or about the 15th of each month between January and June, we performed systematic aerial surveys for colonies, with observers on both sides of a Cessna 182, flight altitude at 800 feet AGL, and east-west oriented flight transects spaced 1.6 nautical miles apart. These conditions have been demonstrated to result in overlapping coverage on successive transects under a variety of weather and visibility conditions, and have been used continuously since 1986.

Once colonies are located, we noted positions with an aircraft-grade GPS unit, with the airship positioned approximately over the north end of the colony, and estimated numbers of visible nesting birds while circling at a variety of altitudes (200 – 800 feet AGL). At small colony sizes (<100 nests), the proportional error in estimating numbers is generally small. However, as colony size grows beyond that, the bias is generally to underestimate numbers (Erwin 1982, Prater 1979), and controlled experiments with simulated counts have demonstrated both large bias (cf 40%) and large inter-observer differences in bias (Frederick et al. 2003). In addition, the latter study also demonstrated that bias can be greatly reduced (by approximately half) through the use of counts of aerial photographs taken at the time of survey. For this reason, in this study photographs of the larger colonies were taken from overhead and multiple angles, and counted later via projection. Due to the extremely large numbers of nests at the Alley North (=Rescue Strand) colony, we adopted some new techniques for estimating numbers of nests from the air. The majority of birds were nesting underneath the tree canopy, leading to a likely massive undercount using aerial estimation and photographic methods. We therefore counted the numbers of nests on the ground in quadrats of known size, and then compared these counts with aerial estimates of nests in the same area. The quadrats were marked on the ground with 4’X4’ blue or silver tarps at the corners in such a way that they could be seen in photos taken from the air. This comparison allowed us to derive a correction factor to apply to the raw counts from aerial photos, in order to achieve an estimated total number of nests.

Systematic ground surveys of colonies by airboat were done in all areas at least once per season, between early April and late May, and were designed to locate and document small colonies or those of dark-colored species that are difficult to detect from aerial surveys. GPS-guided belt transects were generally in north-south orientations, and were also designed to give overlapping coverage. The width of belt transects varied between 0.5 nautical miles apart in extremely open habitat of southern WCA 3, to 0.2 nm spacing in the heavier cover of Loxahatchee NWR, and depended on ongoing assessment of the visibility of colonies on adjacent transects. Where islands were widely spaced, we could keep mental track of a wider field of view, and so the width of the belt transect would increase in order to maximize efficiency. All tree islands were approached closely enough to flush nesting birds, and nests were either counted directly, or estimated from flushed birds.

It should be clear that this flushing technique works only for smaller colonies, since in large colonies the counting is much more difficult, and many of the birds in the interior would not flush. These large colonies were generally few in number and were counted by a combination of aerial survey estimation and photo-counts for white-colored species (as above and following paragraph), and walk-through counts. A classic example of how these techniques are combined is shown by the "Hidden" colony (also called in previous years "L-28", and "40-mile bend") located in extreme southwestern WCA 3. This colony has substantial numbers of Great Egrets, and large numbers of Snowy Egrets, Tricolored Herons, Anhingas and Little Blue Herons. The colony is largely in dense cypress woods, and visibility from the ground is limited to tens of meters. The Great Egrets and Snowy Egrets are typically counted from aircraft at what was perceived to be their maximum density during incubation periods (February or early March for GREG, late March or April for SNEG). The Tricolored Herons, Anhingas and Little Blue Herons were systematically counted during incubation stage on foot, using 3 – 6 observers walking abreast, spaced 5 – 15 m apart along compass lines. Nests of the three small herons (Snowies, Tricoloreds and Little Blues) are indistinguishable unless chicks are present. Generally, Snowy Egrets nested in groups that were discernable as the birds flushed. Where chicks were not present, we estimated species proportions of nests based on numbers of birds flushed from particular areas.

We also have become aware of a further, general problem in estimating numbers of nests – that of estimating numbers of nests not present at the time of survey, but which do occur at some point during the nesting season. There are currently no existing techniques to deal with the resulting tendency to underestimate nesting numbers over a season, and the problem is currently a subject of active research. While there may be important implications for the accurate estimation of total breeding population size, it is clear that the estimates contained in this report are at the least likely to be similar in bias to those reported from surveys since 1986. It is also safe to say that by comparisons with surveys prior to 1986, the techniques we have used are considerably more systematic in both time and space, and therefore likely to underestimate breeding populations less than earlier attempts.

Results

Nesting effort:

As is typical for the Everglades, the numbers of ibises dominated the total counts (over 50%) and were also the most difficult species to count accurately. This is partly because many of the nests are located under the canopy and thus cannot be seen from the air, and partly because annual nesting is comprised of asynchronous but overlapping cohorts, which are nearly impossible to distinguish from one another. We therefore suspect that the number of ibis nests we report here is quite conservative as an estimate of total nest starts; modeling of the asynchrony and the visual occlusion errors suggests that our direct peak counts underestimate true numbers by at least 50%.

We have reported in Tables 1.2 & 1.3 that about 30,000 ibis nests were initiated in the WCAs of the Everglades, based on peak estimates made using fixed-wing aerial estimates and slide counts, and some educated guesses about the numbers of birds nesting under the canopy. The error due to asynchrony was not figured into this total estimate, however.

Total counts in the WCAs and Loxahatchee NWR: Combining all species at all colonies in LNWR, WCA 2, and WCA 3, we estimated a grand total of 46,177 nests of wading birds (Cattle Egrets, Anhingas and cormorants excluded) were initiated between February and July of 2004. Note that this figure does not include birds nesting at the Tamiami West and East colonies, which we also monitored intensively in ENP (see Appendices 1.1 and 1.2).

For perspective, the size of the nesting aggregation in 2004 in the WCAs and LNWR combined was 2.2 times the average of the past ten years, 1.3 times the average of the last five years, and 1.7 times the total nesting in 2003. Numbers of Great Egret nests were 1.1 times the average of the last five years, and 1.6 times the last ten. In 2004, Wood Stork nests were 0.54 times the average of the last ten years, and 1.06 times the average of the last ten years. White Ibis nests were 3.1 times the average of the last ten and 1.6 times the average of the last five years.

In terms of total numbers, the 2004 nesting event can be considered a large and important one, ranking second largest in the 19 years during which systematic surveys have been conducted in the WCAs. This continues a recent trend towards distinctly larger numbers of total nesting attempts. Since 1999, 6 of the 7 largest nestings in the 19-year history have been recorded (1992 being the only outlier). In fact there appears to be a distinct trend towards larger nesting numbers since 1998 (see Chapter VI) that suggests either that the Everglades has had consistently favorable conditions for nesting since 1999, or that something fundamental has changed about the ability of the ecosystem to support large breeding populations of wading birds.

Nesting Success:

Wood Storks: (see also more detailed information in later section on Wood Stork reproduction). Storks initiated nesting somewhat late even by the standards of the last 20 years. They were nesting at TTW and Crossover and in courtship at Jetport by late February but did not achieve peak numbers until early March. Birds at TTW began abandoning nests in response to heavy rainfall in early March, and no nests were found in surveys by the third week in March. Similarly, the birds courting at Jetport disappeared at about the same time. However there was no evidence of abandonment at Crossover colony and the birds there appeared to have fledged substantial numbers of young. By mid-April what appeared to be many of the birds from TTW apparently re-nested at the 3B Mud East colony (82 pairs) but none of these nests appear to have fledged young. Similarly new nests started up near Jetport (Jetport south, 29 pairs), and their fate was unclear. Some abandonment probably occurred at Paurotis Pond in ENP, but most of these nests produced young, and most (75%) had three chicks in the latter part of the nestling period. Cuthbert Lake also appeared to fledge young from most nests. It is important to remember that most of the late initial and re-nesting events would certainly have failed entirely if the onset of summer rains had not been delayed by over a month (early July).

We did not note large abandonments of Great Egrets at any of the colonies we studied intensively (Alley North, TTW, Hidden, False L-67), nor did we see evidence of abandonment at other colonies monitored monthly. Although the nest success data has not yet been analyzed using Mayfield's method, Great Egret nests did appear to be largely successful (84% of nests monitored succeeded. Although we did not see evidence of nest failure on any of our intensively visited White Ibis nest check transects (63% of nests monitored succeeded), there is some information that suggests abandonments at both Alley North and Lox 70 sometime in early March.

The very obvious abandonments by storks and the lack of it by Great Egrets and to a lesser extent the ibises was puzzling, since stork and ibis abandonments usually co-occur, and poor years for storks are often marked by poor nesting success by Great Egrets. In 2004, however, the timing may have been key. The storks abandoned fairly early in March at a time when ibises were only just beginning to nest. So the slightly later than usual nesting by ibises (late March) may have put them out of risk of the same conditions that caused storks to abandon.

Table 1.2. Numbers of nest attempts in WCAs 2 & 3 between January and July, 2004. "All Waders" totals do not include CAEG or ANHI.

Area	Latitude		Longitude		Colony	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLIB	CA
3A	26	12.125	80	31.748	Alley North	1,000	16,000		200	10	600	200	1,000	200	10		150	
3A	25	46.360	80	50.240	Hidden	165	2,480		150		685		1,160					
3B	25	48.080	80	29.400	3B Mud East	350	1,153	82	53	5	141	190	45	65				
3A	25	46.615	80	50.558	Hidden North				8		383	4	787	4				
3B	25	47.755	80	29.490		335												
3A	25	55.510	80	50.100	Crossover	150		150										
3A	26	07.320	80	32.500	Cypress City	180												
3A	26	07.440	80	32.608		180												
3A	26	01.480	80	32.360	Donut	175												
3A	26	03.769	80	43.294			150											
3A	25	54.760	80	37.870	False L-67	135			20	15								
3A	26	06.110	80	27.270	Holiday Park	140												
3A	26	02.750	80	37.100	Big Mel	130												
3A	26	07.720	80	42.100		130												
3A	25	52.110	80	50.610	Jetport	130												
2B	26	07.780	80	20.740	2B Mel	125			50						5			
3A	26	07.970	80	42.160		125			50						5			
3A	26	07.330	80	30.200		120												
3A	26	07.400	80	30.380		117												
3A	25	56.410	80	37.250	Starter	95			15	3								

3A	25	57.880	80	34.480	Mel L67	95												
3A	25	59.006	80	48.776							21			64				
2B	26	10.930	80	19.770		80												
3A	25	49.235	80	40.632		75			2									
3A	26	07.640	80	43.443							18			48				
2A	26	14.806	80	19.666		65												
3A	25	46.270	80	41.600		65												
3A	26	07.720	80	42.100		65			1									
3B	25	55.400	80	31.140		63												
3A	26	00.270	80	49.191			56											
3A	25	48.450	80	51.920	South Jetport	25		29										
3A	25	58.276	80	42.086		50			10	1								
3A	26	02.263	80	45.715	Mud Canal	15												55
						673	116	6	562	356	99	42	5	164	0	21	0	0
		Total, WCAs 2 & 3				5,053	19,955	267	1,121	390	1,947	436	2,997	545	20	21	150	55

Table 1.3. Numbers of nest attempts of wading birds in Loxahatchee National Wildlife Refuge, January through July of 2004. All Waders totals do not

Area					Colony	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLIB	CAE
LOX	26	26.250	80	14.580	Lox 70		8,000											
LOX	26	26.350	80	23.510	Lox 99	220	1,000											
LOX	26	27.523	80	14.395		300	350		200		25	10	50	40			20	50
LOX	26	28.130	80	22.324		300			50			30						
LOX	26	31.338	80	15.814		25	100	4	35		30	11	125	7			22	
LOX	26	27.450	80	14.200		300												
LOX	26	22.960	80	15.320		259												
LOX	26	33.580	80	15.060	Canal North		250											

LOX	26	31.910	80	17.693	32					25	4		60				
LOX	26	27.439	80	21.244	20			4		2	3		90				
LOX	26	27.009	80	15.798				1		12			100				
LOX	26	33.225	80	15.058	80		20										
LOX	26	22.310	80	18.570	95												
LOX	26	33.041	80	15.012	90												
LOX	26	27.751	80	22.358				42					87				
LOX	26	31.174	80	19.135							2	2	80				
LOX	25	59.791	80	39.507				20	1		35		45				
LOX	26	22.181	80	15.475	80												
LOX	26	26.842	80	16.537	5								75				
LOX	26	29.528	80	22.339						80							
LOX	26	31.855	80	17.687						5	1	12	54				1
LOX	26	29.536	80	22.353				3		5			60				
LOX	26	22.400	80	16.080	60												
LOX	26	22.800	80	15.100	60												
LOX	25	58.237	80	42.031	55			6	1								
LOX	26	23.860	80	15.150	55												
LOX	26	32.999	80	15.088	50			22	2								
LOX	26	31.861	80	17.702						4		12	36				
LOX	26	22.650	80	15.660	50												
Totals, colonies less than 50 pairs					278	4	3	267	231	46	178	40	441	0	0	50	35
Total, all colonies in Loxahatchee NWR					2,414	9,704	27	650	235	234	274	241	1,175	0	0	92	86
Total, all colonies in all WCAs in 2004					7,467	29,659	294	1,771	625	2,181	710	3,238	1,720	20	21	242	141

Reproduction, Survival and Movements of Juvenile Everglades Wood Storks in 2004

This was the third year of an ongoing study examining the movement patterns of juvenile Wood Storks, *Mycteria Americana,* and the factors that may affect their survival. Due to their sensitivity to hydrological conditions in the Everglades, Wood Storks have been proposed as indicators of restoration success and are a key objective in restoration plans for the south Florida ecosystem. Wood storks were once abundant in south Florida, but their numbers have declined precipitously since the 1960's due to habitat loss, dramatic changes in water management and other types of degradation of the Everglades (Ogden 1994, Coulter et al. 1999). Although the species has been federally listed as endangered since 1984 (USFWS 1999), population dynamics for the species remain poorly understood (Coulter et al. 1999). Among the data that have been lacking for the species are age at first breeding, fledging success, juvenile survival, and annual survival of adults (Coulter et al. 1999). Factors affecting mortality rates for young and adult wood storks are also poorly understood. Cumulatively, these information gaps mean that it is currently impossible to predict population trajectories, and to establish levels of reproduction that will result in demographic replacement for the population.

An understanding of wood stork population dynamics in the Southeast is complicated by their extensive range and extreme vagility. It is thought that most wood storks use Florida wetlands at least occasionally as a winter range and wood storks fledged in south Florida regularly leave south Florida during the summer months, taking up temporary residence in northern Florida, Georgia, South Carolina, and Alabama. During the breeding season wood storks may move between colonies if local environmental conditions are unfavorable (Ogden and Patty 1981). Genetic evidence also suggests that there are high migration rates and interbreeding between subpopulations (Coulter et al. 1999). These high rates of interchange among individuals from different colonies support the treatment of the wood stork in the southeast as a single population.

While it is known that Wood Stork foraging behavior is closely tied to hydrological conditions, little is known about their movements and the specific habitats they use. The ways in which individuals utilize their environments are critical to their survival (Bergman 2000, Austin et al. 2004). For the Wood Stork, at no time is this more critical than during the fledging and dispersal of young birds from their colony. Young birds are likely to face the highest mortality probabilities of their lifetimes during the first six months of life (Frederick 2002, Gill 1990); during this time habitat quality and the ways in which young birds respond to their habitat may be crucial to the demography of the species as a whole (Zollner and Lima 1999, Bergman et al. 2000, Austin et al. 2004). Prior to the start of this study, first year survival rates had been virtually unknown. Palmer (1962) estimated that storks have a 60% chance of survival during the first three months following fledging, followed by an 80% chance of living per year after this time and J. C. Ogden estimated a less than 50% survival rate during the first year of life for a Wood Stork during years of poor foraging conditions (Frederick and Spalding 1994). Due to the potential importance of early survival on the population dynamics of the species, we have focused on following stork survival during the incubation, nestling and fledging periods. In addition, we looked at the factors affecting the nestling health and later survival of these young storks and the sensitivity of Wood Stork population dynamics to variability in fledging and first-year survival rates.

The destruction and alteration of natural habitats is the primary cause of species endangerment (Czech and Krausman 1997, Wilcove 1998, Czech et al. 2000).

Due to the shift in stork demographics and wetland abundance and quality over the past 30 years, we decided to also investigate the habitat use and movement patterns of juvenile Wood Storks across the southeastern United States. By analyzing movement and habitat-use in relation to survival, we can begin to identify wetlands and other areas that are heavily used and gain insights into the quality of this habitat for the species. This information is crucial for enhancing the management of the broader southeastern U.S. population and the habitats upon which the population depends.

The lack of information on juvenile and adult survival rates has precluded the development of a credible demographic model for this species to date. Given the known fecundity and the range of demographic parameters for this species, preliminary modeling results suggest that population dynamics are likely to be sensitive to juvenile survival rates. While measuring adult survival rates has been beyond the scope of this project, our measurements of nesting success and nestling and juvenile survival data will provide us with a basis for beginning the development of a demographic model of the species. This model can help inform decisions regarding the conservation and management of the U.S. population of Wood Storks.

The objectives of this project were to describe the movements and measure the survival of fledging and juvenile storks through the first year or more of life, using satellite and conventional VHF radio telemetry as the primary research tools. We also hope to follow individuals tagged as part of this study to identify the age at which individuals start reproducing. As potential determinants of survival, we have utilized information on hatch order, health at time of marking, habitat types used, and movement patterns. We also intend for this work on juvenile storks to be a first step towards filling in the demographic picture of this species, which could later be coupled with additional research on adult storks. As a by-product of this work, we developed an interactive web site for educational use, focusing on the biology of wading birds and the dynamic movements of the study group of storks.

Methods

We systematically surveyed for Wood Stork colonies from February to June 2004 throughout Water Conservation Areas 1, 2 and 3 using fixed wing aircraft. In addition to the 2 major stork colonies that developed in the WCA's (Crossover and 3B Mud East), we also monitored the Tamiami West and Paurotis Pond colonies located within Everglades National Park from the ground and air and the Palm Beach County Solid Waste Authority (SWA) colony from the ground. Each Wood Stork colony was surveyed to determine layout of the colony, nesting stage, and numbers of nests. Due to the early abandonment of the Tamiami West colony in late February, we chose to follow nesting success intensively at the Palm Beach County Solid Waste Authority (N26º46.41, W80º08.32). The SWA colony was easily accessible, had wildlife viewing towers that aided observations, hosted a large number of nesting Wood Storks, and had stork nests that were easily accessed by climbing or by ladder.

Although storks nesting in Paurotis Pond (N25º16.89, W80º48.18) were also easily reachable by ladder, accessibility to this colony within Everglades National Park was limited due to visibility to the public. Furthermore, reports of widespread nest abandonment early in the nesting season raised concerns about the feasibility of using the colony for our satellite tagging study.

Reproductive Success

The SWA colony occurs on dredge spoil islands in a flooded borrow pit on the property of the Palm Beach County Solid Waste Authority. Approximately 240 Wood Stork nests were initiated in the SWA colony in 2004. Nests were selected for inclusion in this study on 7 islands throughout the borrow pit. Only nests occurring on Brazilian pepper (*Schinus terebinthifolius*) were included in the study. Other nests were located high (> 5 m) in Australian pines (*Casuarina sp*.) and were not accessible for our study. Although nests were not randomly selected, we attempted to mark a good cross-section of the nesting population by including nests from both sides of the borrow pit (east and west of the central open-water area) and both edge and more centrally-located nests. A total of 91 nests were marked with numbered surveyors flagging.

We followed the nesting success of each of the 91 nests every 5-10 days throughout the nesting season. Variations in our schedule were necessary to minimize disturbance during critical nest building and egg-laying stages of Wood Storks and the many other wading bird species that use the rookery. We truncated the nesting information for Mayfield analysis on the last date that nest ID was known if nests became unidentifiable for any reason.

We used three-meter long mirror-poles to view nest contents and determine numbers of eggs and young. Estimates of the approximate age of chicks were based on size, feather growth, and presence of flight feathers (Kahl 1962). Storks were considered to be at least 4 weeks of age when they had visible white contour feathers on the back and coverts and primaries 5-8cm in length. For the Mayfield analysis, chicks were considered fledged by day 50. In cases when a full clutch had not yet been completely laid, or a chick in a nest was hatching on the nest check date, we used the Mayfield method to pro-rate nest initiation dates.

At the initial time of marking, only 8 of these 91 nests had hatched young. The average clutch size of marked nests located during incubation was 2.88 (SE=0.083, n=83). Average brood size for nests monitored when at least 1 nestling was 45 days old was 1.94 (SE=0.097, n=52). Overall traditional nesting success (number of nests fledging young /number of nests studied) for this colony was 58.24% (53/91 nests). We also used Mayfield's method of analyzing nesting success, which pro-rates survival on a daily basis (Mayfield 1961). During the incubation stage, Mayfield survival was 51.75%. Survival was higher during the nestling phase, increasing to 89.83%. The overall, combined Mayfield nesting success for these two periods was 46.49%.

Nestling health

After nestlings reached 4-5 weeks of age, 24 first-hatched nestlings were randomly selected for inclusion in our health and telemetry studies. Due to the irregular layout of the colony, we identified the spoil islands with the most nests containing first-hatched chicks of the appropriate age. First-hatched nestlings were preferred over later-hatched nestlings to avoid the non-independence effect of siblings and to control for biases related to hatching order. All nestlings were caught by hand on the nest and immediately hooded to reduce stress. Work in colonies took place only during early morning hours, when thermal stress was lowest, and when the possibility of interrupting feedings by adults was at a minimum.

After a juvenile stork was captured, we marked the nest number, number of siblings, and whether the captured bird was the oldest in the nest (by visually assessing culmen length). After cleansing a leg or underwing with alcohol, we drew up to 2mL of blood from the ulnar or brachial veins. In our sequence of handling, blood was collected first to ensure we had time to tell that bleeding had fully stopped and no complications had arisen before returning the bird to its nest. Blood was used for sexing, hematocrit, white blood cell counts, and presence of blood parasites. We fitted U.S. Fish and Wildlife Service individually numbered aluminum leg bands and, in 2004, PVC alphanumeric color bands in a white on green pattern to each bird and recorded culmen and tarsus lengths (nearest mm), and mass (nearest g) to develop an index of body condition (Brown 1996). Each health exam also included a physical examination for oral parasites and ectoparasites, and palpation for *Eustrongylides* nematodes in the abdomen (Spalding et al. 1994). In addition, 4 – 6 growing scapular feathers were collected from each bird to determine level of mercury contamination.

Satellite telemetry

Following the health exam, each bird was fitted with a backpack harness that carried a 10g VHF radio transmitter and a solar-powered ARGOS certified platform transmitter terminal (PTT) for satellite tracking. To improve the precision of our locations, this year we added 17 45-gram GPS/PTT solar-powered satellite transmitters from Microwave Telemetry to our program. We also reused 7 35-gram PTT transmitters that had been refurbished from previous years. The total weight of the Teflon harness, VHF transmitter and PTT did not exceed 3% of the Wood Stork's fledging mass (2 – 2.8 kg) in accordance with recommendations from the Office of Migratory Bird Management, U.S. Geological Survey.

Signals from the PTTs are recorded by polar-orbiting environmental satellites. The ARGOS/GPS PTT obtains hourly GPS fixes over 16 consecutive hours and transmits them to ARGOS every 3 days. The refurbished 35-g PTTs aquire location data by measuring the Doppler shift in signal frequency among satellites; this data is then processed by ARGOS Satellite Location and Data Collection System, Landover, MD (Argos 1996). The 35-g PTTs work on a 10 hour on/24 hour off cycle. Argos assigns each fix to a location class (LC) based on their accuracy estimates. Only locations with estimated accuracies of <1000m (LC=3, 2, or 1) are being used in this study, however locations with estimated accuracies of >350m are preferred (LC=3 or 2). The GPS-PTTs are estimated to be accurate to within 18 meters.

Location information from ARGOS was received by email, and converted into an Excel spreadsheet database. Once in the database, the location information was managed on a weekly basis, and each quality location point was inspected to prevent duplicates and to monitor the survival of individuals. Location data for each individual was then converted to dBase format and uploaded into ESRI ArcView 3.2. Movement patterns and habitat use will be analyzed using Hooge and Eichenlaub's (1997) Animal Movement Analysis ArcView extension which runs through the ArcView Spatial Analysis extension.

We monitored the survival of tagged birds prior to fledging using ground visits to the colony and using VHF and satellite transmitter data. VHF transmitters are equipped with a mortality sensor that is motion sensitive. If there is no movement from a tagged bird for 18-24 hours, the transmitter's signal becomes twice as fast as normal. We identified mortalities when we stopped receiving an individual's PTT data, suspected unusual activity, or heard mortality signals from the VHF transmitters. While in the colony, VHF frequencies were monitored daily; after fledging, monitoring of satellite data was the primary method used to identify mortalities. When a mortality was suspected from the satellite data, we used the last PTT-derived location for that bird as a guide for where to search using VHF telemetry. We attempted to retrieve all transmitters from dead birds for which we located their VHF signal.

Harness design and attachment

Larry Bryan of Savannah River Ecology Lab developed a backpack harness for satellite transmitters placed on adult Wood Storks in which he attached four pieces of Teflon ribbon to a transmitter, fitted each harness to the exact dimensions of the bird in hand, and secured the ribbon pieces on the bird's chest with a metal grommet (Larry Bryan, personal communication). For this project, we slightly modified Bryan's design by sewing two pieces of Teflon ribbon to the transmitter prior to having the bird in hand. For a complete description of the harness design see Hylton (2004).

Since storks were not yet fully grown at the time we fitted the harness, the harnesses could not be firmly fitted to each bird for fear of a resulting constriction on the bird. At 4-6 weeks of age, juveniles are still noticeably smaller than adults, with culmen length at fledging 50mm shorter than those of adults (Clark 1978). To accommodate growth of juveniles, we designed an adjustable harness that would fit adults and juveniles. Ribbon lengths were determined by slightly expanding maximum dimensions of captive male and female Wood Storks measured at Homosassa Spring Wildlife State Park, Homosassa, Florida.

Harnesses were designed to fit securely, yet allow plenty of room for size variability among individuals. We stitched a single polyester elastic thread (56% polyester, 44% rubber) along the length of each Teflon ribbon to provide a closer fit to a juvenile bird. When stretched taut, the ribbon easily expanded to its full length, however when relaxed, the elastic resulted in a mild bunching along the length of the ribbon that held the transmitter in place more firmly on the bird.

With the hooded bird in hand, the anterior Teflon neck loop was slipped over the bird's head and neck so that the transmitter rested centrally on the bird's mid-back. The unattached end of the side ribbon was then drawn under one wing, looped once through the neck loop on the chest, and drawn across the chest and under the opposite wing. After ensuring flight feathers were not obstructed and the ribbon was lying flat on the bird's body, the free end of the ribbon was looped through the remaining free side attachment point on the transmitter and stitched closed in the manner previously described. After minor adjustments for central placement of the transmitter on the back of the bird, the point at which the two ribbons overlapped on the chest of the bird was stitched to ensure a better fit and prevent unnecessary sliding of the transmitter along the back until the bird reached full size. New stitchings were further strengthened using a drop of liquid anti-raveling agent. Each harness was double checked to ensure proper fit for the bird, after which we removed the hood from each bird and returned it to its nest.

Statistical Analysis

In 2004, as in previous years, we tested for preferential habitat use by juvenile storks by comparing a 95% fixed kernel density utilization distribution to the total habitat available within the entire range for all tagged storks. We defined available habitat as the area within a minimum convex polygon (MCP) of all telemetry locations for all birds, minus the areas covering the Atlantic Ocean and Gulf of Mexico.

As in previous years, we tested the null hypothesis that habitat use was random with respect to the habitat categories chosen. We analyzed habitat use for 2004 birds separately from birds surviving from previous years. For 2004 birds, we used locations for all birds that survived more than 3 weeks from fledging. A bird was considered fully fledged once all telemetry locations exceeded 1 km from the colony. For birds that had been tagged in prior years, we used all good locations collected between 1 January 2004 and 28 February 2005. To avoid autocorrelated telemetry locations, we used a maximum of one location per day in this analysis. When multiple locations were available on a given date, we selected one location on the basis of the following criteria: for the standard PTTs, we chose the earliest, best quality location (LC 3>2>1), while for the GPS/PTTs we randomly chose one point per Julian day.

We compared matrices of the log-ratios of proportions of used habitats to the log ratios of proportions of available habitat using a Wilks lambda test using the "compana" routine in the statistical software package R. If habitat use was determined to be significantly different from random, we constructed a ranking matrix of habitat use indicating whether the habitat in the row is used significantly more or less than that in the corresponding column. We also tested the null hypothesis that there is no difference in habitat use between older and newly fledged birds by using standard t-tests of proportion of habitat used adjusted by a Bonferroni correction (significance established at $p = 0.0065$).

As in previous years, we used 1995 vegetation coverages from the National Land Cover Data set (United States Geological Survey). These coverages provide a uniform habitat classification scheme across the range of focal storks (Florida, Georgia, Alabama, and South Carolina in 2004) with 30 m resolution. We pooled similar habitats for a total of 8 habitat categories: 1) open water, 2) developed (low intensity residential, high intensity residential, and commercial/industrial/transportation), 3) barren (bare rock/sand/clay, quarries/strip mines/gravel pits, and transitional), 4) forest (deciduous forest, evergreen forest, and mixed forests), 5) shrubland, 6) cultivated (orchards/vineyards, pasture/hay, row crops, small grains, fallow, and urban/recreational grasslands), 7) grassland/herbaceous, and 8) wetland (woody wetlands and emergent herbaceous wetland.

Results

Reproductive success

At the initial time of marking, only 8 of these 91 nests had hatched young. The average clutch size of marked nests located during incubation was 2.88 (SE=0.083, n=83). Average brood size for nests monitored when at least 1 nestling was 45 days old was 1.94 (SE=0.097, n=52). Overall traditional nesting success (number of nests fledging young /number of nests studied) for this colony was 58.24% (53/91 nests). We also used Mayfield's method of analyzing nesting success, which pro-rates survival on a daily basis

(Mayfield 1961). During the incubation stage, Mayfield survival was 51.75%. Survival was higher during the nestling phase, increasing to 89.83%. The overall, combined Mayfield nesting success for these two periods was 46.49%.

Nestling Health

Of the 24 nestling storks tagged in 2004, only one died before fully fledging from the colony. Predation was suspected as the cause of death for this individual. Alligators were numerous at this colony, and the VHF signal associated with the missing bird was tracked to a medium-sized alligator.

Satellite Telemetry

Between 6 May and 2 June 2004, we placed a total of 24 transmitter harnesses on juvenile Wood Storks between 4 and 6 weeks of age. Prefledged storks were visually monitored on subsequent visits to ensure that harness fit was not hampering movements or agility of the birds. Many individuals with transmitters were observed flying away unimpeded when disturbed from their nest or roost. Twenty-three of the 24 tagged birds fledged successfully from the colony (95.8%). As of 15 December 2004, we have relocated a total of eight PTTs and nine VHF transmitters. We will reuse these transmitters in spring 2005.

We received substantially more good quality location information from birds harnessed with the GPS-PTT than from those with refurbished PTTs. For the period between 1 June and 9 November 2004, we received GPS locations on each "GPS-bird" approximately 63.15 times per week (range 50.07 – 82.23) and on each "PTT-bird" approximately 5.95 times per week (range 2.33-12.35).

Fledgling survival

Of the 24 birds tagged with satellite transmitters, satellite data suggests that 14 have died as of 28 February 2005 (41.67% survival). Of those 14 mortalities, only 1 occurred within the borders of the colony. Of the 13 mortalities that occurred outside the colony, all occurred in Florida. The first 7 mortalities occurred within 60 days of permanently leaving the colony, and the 8th occurred on 2 September 2004, approximately 70 days of the individual leaving the colony. The remaining birds survived through early November, with 5 deaths occurring between 8 and 20 November 2004. We found tags and the remains of 6 birds in cattle pastures, 2 in state- or federally-owned conservation lands, and 2 tags were heard but not recovered at mines (1 sand and gravel mine, 1 phosphate mine). Tags associated with other mortalities were not located or recovered.

Movement patterns

Prior to leaving the colony permanently, most of the juvenile storks we tagged made use of the West Palm Beach Water Catchment Area just west and south of the rookery. Dispersal patterns differed this year from those observed in the previous two years. While young storks tagged in 2002 and 2003 moved northward and out of the Everglades almost immediately after leaving the colony, many of the birds tagged in 2004 moved southward into the Everglades before heading north (Fig. 1). In June and July, 7 birds were located repeatedly in the Water Conservation Areas, 6 in Everglades National Park, and 3 in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Fig 2). This difference in movement pattern was likely due to the delayed onset of the summer rains this past year. Upon leaving southeastern Florida, birds ranged widely across the state and into Georgia, South Carolina, and Alabama (Fig. 3).

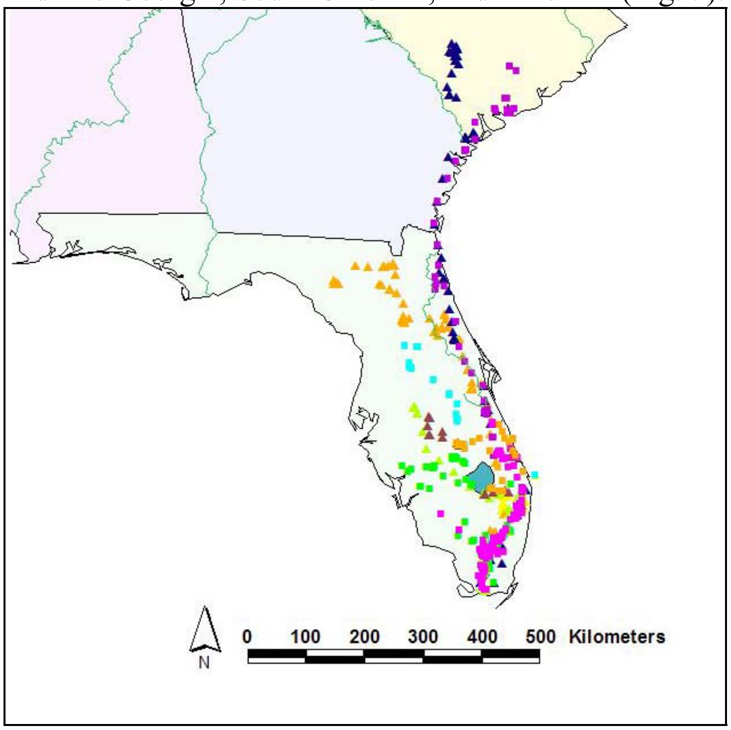

Figure 1.6. Locations of 23 juvenile Wood Storks from 1 June – 15 July 2004. Six storks flew south through the Everglades before heading north. Two birds appeared to be moved up the Georgia coast together, and several other birds followed the same route days or weeks later. Each color/symbol combination represents a different bird.

Of the birds that left the state, 6 established summer home ranges in Georgia, 2 in South Carolina, and 1 bird remained close to the Georgia-Florida border. Eight of the birds remaining in Florida established summer home ranges in the central part of the state, while 3 birds remained southwest of Lake Okeechobee throughout the summer. All migrants had returned to Florida by the second week of November. This is the first year we have had evidence this year of juvenile storks traveling together and foraging together even months after leaving the colony.

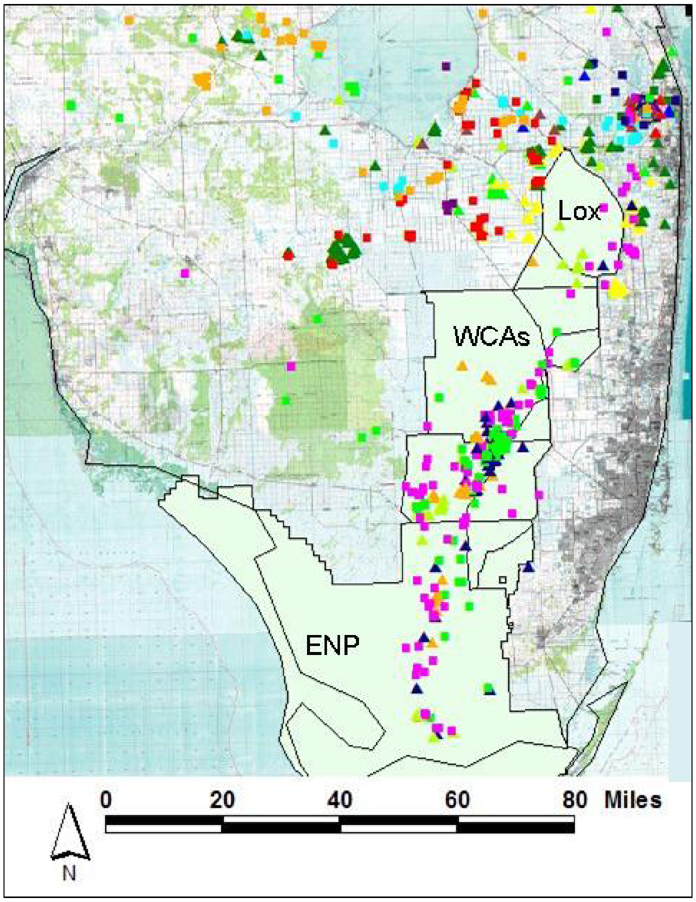

Figure 1.7. Locations of tagged juvenile Wood Storks in south Florida, 1 June – 31 July 2004. Storks moved southward through the historic freshwater Everglades, now comprised of the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Lox), Water Conservation Areas 2 and 3 (WCAs), and Everglades National Park (ENP). Each color/symbol combination represents a different bird.

Of the 27 birds tagged in 2002, 6 are still alive. Survival rates for this cohort were 44.44% the first year, 75% the second year, and 66.7% the third year. The 2003 cohort fared much worse: only 1 of the 17 birds which fledged successfully survived its first year (5.88% survival). Most of these birds remained in Florida through the summer, but 2 did leave the state (Figure 1.8). One bird spent the summer in Georgia, the other in Alabama.

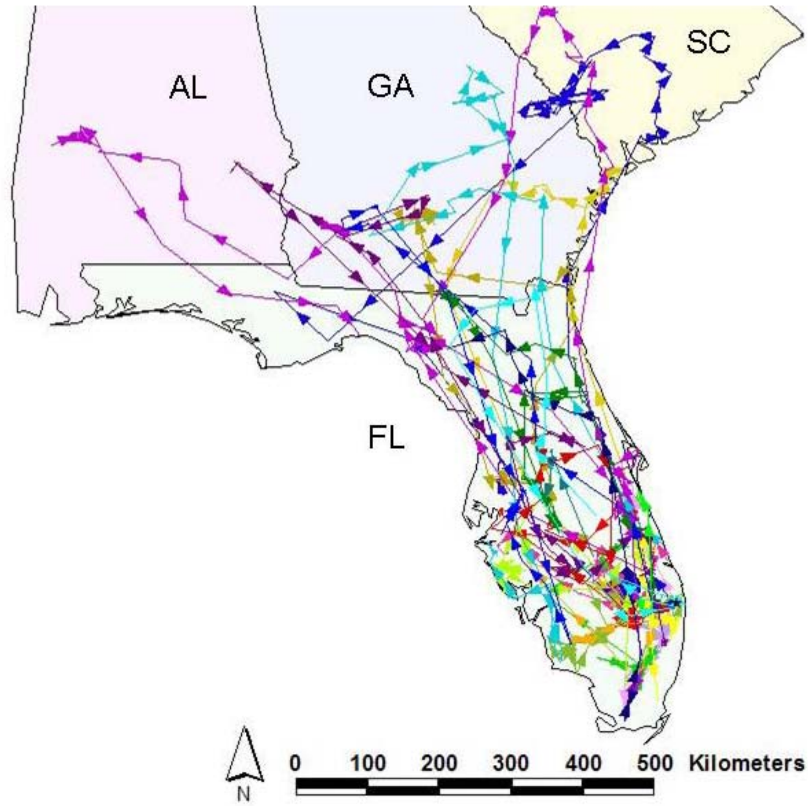

Figure 1.8. Movements of all 2004 tagged juvenile Wood Storks from time of fledging to their death or until 28 February 2005 if still alive. For ease of viewing, each path is based on only one location per day. Each color represents a different bird.

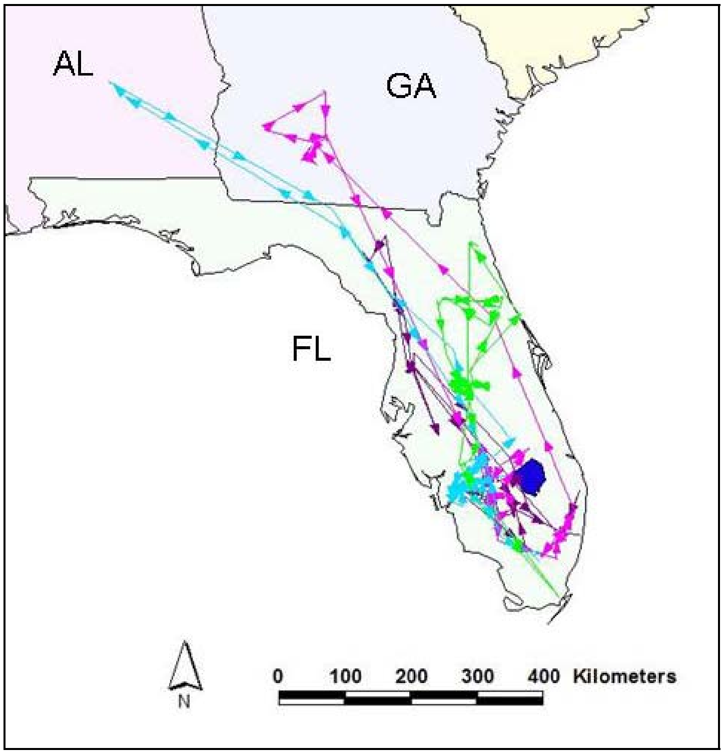

Figure 1.9. Migratory movements of three subadult Wood Storks tagged in 2002. One stork was in Georgia from 10 July 2004 to 29 September 2004, another spent 19 August through 16 September 2004 in Alabama, and a third stork migrated to northern Florida from 9 May to 29 August 2004.

Habitat Use

Habitat use differed significantly from habitat availability for both 2004 birds ($\Lambda = 0.2958$, 7 d.f., $p < 0.001$) and for the 7 older birds ($\Lambda = 0.0413$, 7 d.f., $p < 0.0001$) . For the 2004 birds, the ranking matrix for habitat use indicated use of grassland > developed > wetland > cultivated > open water > shrubland > barren > forest (Table 1.4). For the older birds, the ranking matrix indicated the use of grasslands > open water > wetland > developed > shrubland > cultivated > barren > forest (Table 1.5).

Table 1.4. Simplified ranking matrix of habitat preferences for juvenile Wood Storks of the 2004 cohort based on comparing proportional habitat used with proportional habitat availability across the entire area used by all tagged storks.

	Open Water	Developed	Barren	Upland Forest	Shrubland	Cultivated	Grassland/ Herbaceous	Wetland	Rank
Open Water		---	+++	+++	+	-	---	-	3
Developed	+++		+++	+++	+	+++	-	+	6
Barren	---	---		+++	---	---	---	---	1
Upland Forest	---	---	---		---	---	---	---	0
Shrubland	-	-	+++	+++		-	---	-	2
Cultivated	+	---	+++	+++	+		---	-	4
Grassland/Herbaceous	+++	+	+++	+++	+++	+++		+++	7
Wetland	+	-	+++	+++	+	+	---		5

Signs indicate if a row habitat was used more (+) or less (-) than a column habitat relative to availability. A triple sign indicates a significant deviation from random at *P*< 0.05. Ranks are based on the number of significant differences.

Table 1.5. Simplified ranking matrix of habitat preferences for subadult Wood Storks of the 2002 and 2003 cohorts based on comparing proportional habitat used with proportional habitat availability across the entire area used by all tagged storks.

	Open Water	Developed	Barren	Upland Forest	Shrubland	Cultivated	Grassland/ Herbaceous	Wetland	Rank
Open Water		+++	+++	+++	+	+++	-	+	6
Developed	---		+++	+++	+	+++	---	-	4
Barren	---	---		+	---	---	---	---	1
Upland Forest	---	---	-		---	---	---	---	0
Shrubland	-	-	+++	+++		+	-	-	3
Cultivated	---	---	+++	+++	-		---	---	2
Grassland/Herbaceous	+	+++	+++	+++	+	+++		+	7
Wetland	-	+	+++	+++	+	+++	-		5

Signs indicate if a row habitat was used more (+) or less (-) than a column habitat relative to availability. A triple sign indicates a significant deviation from random at $P < 0.05$. Ranks are based on the number of significant differences

Older birds were more likely than 2004 birds to use wetlands (t = 3.308, 30 d.f., p = 0.0024*) and open water (t = 2.864, 30 d.f., p = 0.0076). Birds that fledged in 2004 were more likely to use cultivated lands (t = 2.995, 30 d.f., p = 0.0055*) and forests (t = 2.105, 30 d.f., p = 0.0437). The median 95% kernel home range size was 22,636 km^2 for younger birds and ranged from 436 – 329,774 km^2 (x = 50443, SE = 16,721) (Fig 5). The median 95% kernel home range size for the older birds was 9653 km^2, with a range from 24 – 59474 km^2 (x = 14,564; SE = 4917) (Fig 6).

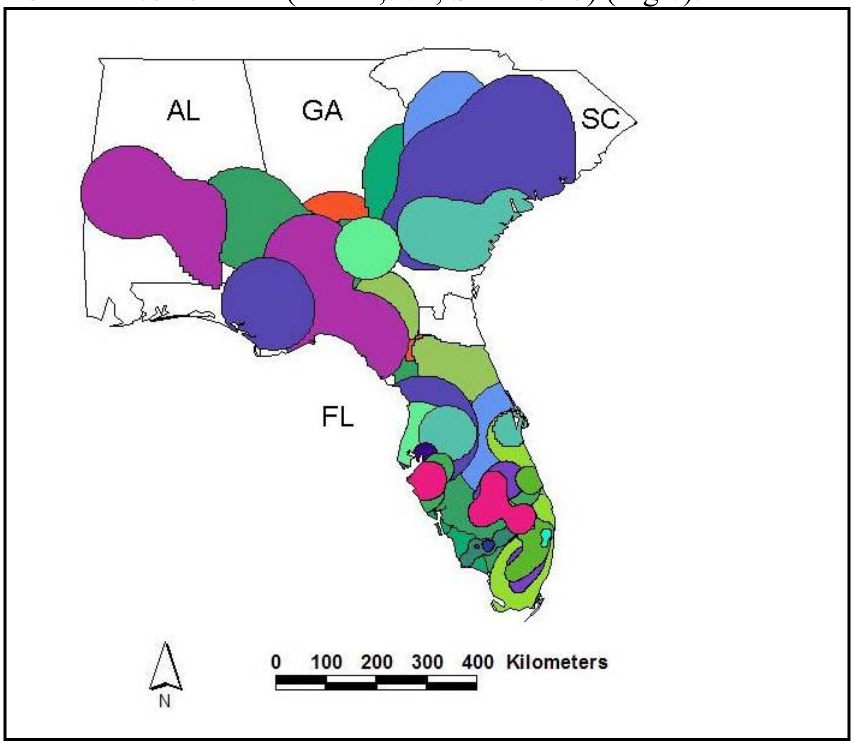

Figure 1.10. Overlapping 95% kernel home ranges for all 2004 tagged juvenile Wood Storks that lived for > 21 days after fledging. Each color represents a different bird's home range.

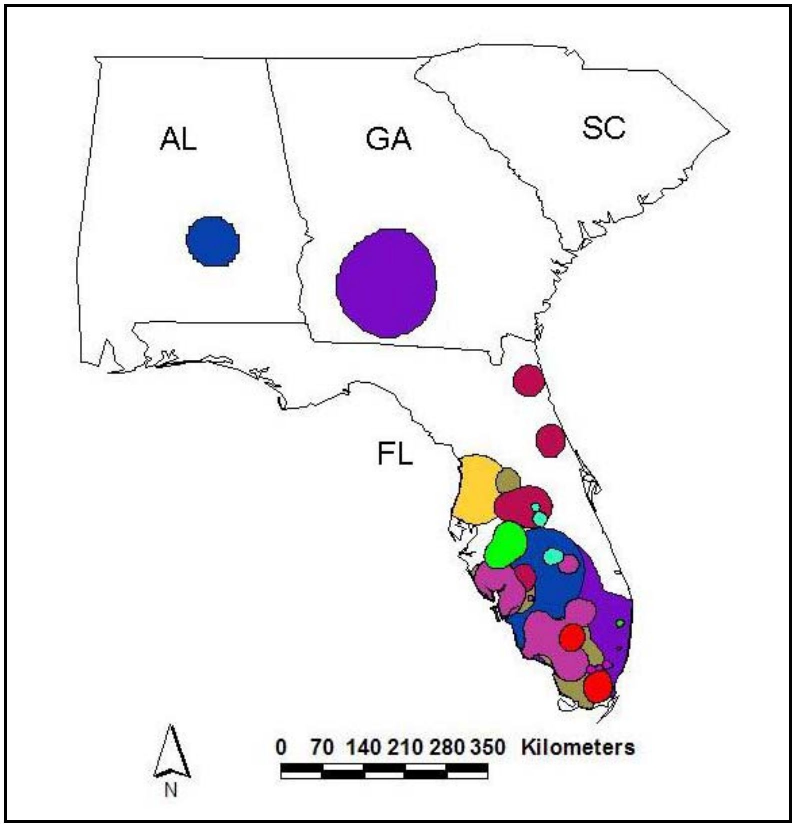

Figure1.11. Overlapping 95% kernel home ranges for birds tagged in 2002 (n = 6 remaining) and 2003 (n = 1 remaining). Each color represents a different bird's home range.

Discussion

This completes a three-year study of the survival and movement of juvenile Wood Storks in the southeastern United States. This study was the first to monitor the survival, movement patterns, and habitat use of juvenile Wood Storks at a landscape scale over multiple seasons. The predictions of the study that juvenile Wood Storks would make heavy use of south Florida wetlands, and wetlands in general, were only partially borne out. In 2002 and 2003, storks spent little, if any, time in south Florida before rapidly dispersing northward. In 2004, however, nearly 25% of tagged birds made use of the freshwater wetlands of the Everglades. While these birds originated in a different colony than those tagged in 2002 and 2003, the differences in behavior following fledging were mostly probably related to hydrology.

Due to a series of storms and heavy rains in February and early March, many early nests failed and many other nests were initiated later than usual in the season (March/April). These nests would have likely failed, or would have required the rapid northward dispersal of fledglings, had it not been for a delayed onset of the rainy season. Weather conditions were relatively dry in south Florida until mid-July. Many of our tagged juvenile Wood Storks were still routinely using the rookery at the Solid Waste Authority throughout the month of July and the last tagged stork to leave the rookery permanently departed on 26 July 2004. Drier than normal conditions would have provided juvenile storks in south Florida with foraging opportunities generally not available during the summer and would have allowed them to remain in south Florida longer than usual.

This year we also observed different trends in broad-scale habitat use by both juvenile and subadult birds than those seen in previous years. While the 2002 cohort showed an expected preference for wetland habitats in 2002, in 2004 we saw a preference for grasslands in both juvenile birds and in birds from the original 2002 cohort. This preference was unexpected, but may have been related to drier than normal conditions throughout the southeast for most of 2004 (www.drought.unl.edu/dm/monitor.html) which may have forced storks into suboptimal habitat. Linkages between habitat use and climate merit further attention.

The majority of satellite tags we recovered were found in cattle pastures (grassland) or other degraded habitats (i.e., agricultural fields, mines). We were unable to determine the cause of death for any of these birds due to the amount of time that passed between the death of the bird and our locating its remains. The prevalence of Wood Stork locations and deaths in these areas raises important questions about possible dangers posed by agricultural chemicals on Wood Stork survival, health, and reproduction. Observational studies of Wood Storks in these habitats, as well as toxicological investigations, may shed some light on this issue.

This project was a first step toward developing a defensible demographic model for the Wood Stork. As a result of this study, we are much closer to parameterizing a population viability analysis for the species. First year survival rates were similar 2002 and 2004 birds, while survival rates for 2003 birds were very low. Another year or two of tagging data should help us understand the impacts of good and bad years on overall population dynamics. Additionally, the tagging of adult birds and of fledglings in other areas remains a priority.

Educational Website

An educational website detailing the ecological requirements and environmental concerns relating to Wood Storks was developed as a result of this project (http://www.wec.ufl.edu/faculty/FrederickP/stork/index.htm). This website focuses on the biology of wading birds and the dynamic movements of the study group of juvenile storks. In an effort to make the movement information available to the public and other professionals, the satellite telemetry project is emphasized on this site and includes maps and descriptions of their movements which are updated bi-weekly. In addition, this site references many other telemetry projects around the world.

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Appendix 1.1 . Numbers of nests by species and colony in WCAs 2 and 3 of the Everglades, 2004.

Area	Latitude			Longitude			Colony	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	G
3A	N	26	12.125	W	80	31.748	Alley North	1,000	16,000		200	10	600	200	1,000	200	10		1[illegible]
3A	N	25	46.360	W	80	50.240	Hidden	165	2,480		150		685		1,160				
3B	N	25	48.080	W	80	29	3B Mud East	350	1,153	82	53	5	141	190	45	65			
3A	N	25	46.615	W	80	50.558	Hidden North				8		383	4	787	4			
3B	N	25	47.755	W	80	29.490		335											
3A	N	25	55.510	W	80	50	Crossover	150		150									
3A	N	26	07.320	W	80	33	Cypress City	180											
3A	N	26	07.440	W	80	32.608		180											
3A	N	26	01.480	W	80	32	Donut	175											
3A	N	26	03.769	W	80	43.294			150										
3A	N	25	54.760	W	80	38	False L-67	135			20	15							
3A	N	26	06.110	W	80	27	Holiday Park	140											
3A	N	26	02.750	W	80	37	Big Mel	130											
3A	N	26	07.720	W	80	42		130											
2B	N	26	07.780	W	80	21	2B Mel	125			50						5		
3A	N	26	07.970	W	80	42		125			50						5		
3A	N	25	52.110	W	80	51	Jetport	130											
3A	N	26	07.330	W	80	30		120											
3A	N	26	07.400	W	80	30		117											
3A	N	25	56.410	W	80	37	Starter Mel	95			15	3							

3A	N	25	57.880	W	80	34	L67	95							
3A	N	25	59.006	W	80	48.776							21		64
2B	N	26	10.930	W	80	20		80							
3A	N	25	49.235	W	80	40.632		75			2				
3A	N	26	07.640	W	80	43.443							18		48
3A	N	26	07.720	W	80	42		65			1				
2A	N	26	14.806	W	80	19.666		65							
3A	N	25	46.270	W	80	41.600		65							
3B	N	25	55.400	W	80	31		63							
3A	N	26	00.270	W	80	49.191			56						
3A	N	25	48.450	W	80	52	South Jetport	25		29					
3A	N	25	58.276	W	80	42.086		50			10	1			
3A	N	25	49.700	W	80	40.632		50							
3A	N	26	02.818	W	80	37.607		40			7	5			
3B	N	25	57.732	W	80	34.325		45							
3A	N	26	08.188	W	80	46.954			15				19		9
3A	N	26	12.677	W	80	39.855		38							
3A	N	25	58.420	W	80	42		37							
3A	N	25	49.200	W	80	41		35							
3A	N	25	53.348	W	80	48.255					15				35
3A	N	25	55.201	W	80	47.921					1			2	30
3A	N	26	08.601	W	80	44.940			31						
3A	N	26	06.779	W	80	44.673		10	5				15		
3A	N	25	52.487	W	80	39.213		30							
3A	N	26	06.734	W	80	44.736		12					14		3
3A	N	26	06.840	W	80	39		27							
3A	N	26	03.017	W	80	40.668			26						
3A	N	25	47.310	W	80	51.171		26							
3A	N	25	45.504	W	80	47.842		25							
3A	N	26	00.829	W	80	37.850		20			6	4			

3A	N	25	49.101	W	80	36.212		23									
3A	N	25	49.550	W	80	38		8	15								
3A	N	25	58.667	W	80	48.292								5	3	15	
3A	N	26	07.970	W	80	42		22									
3A	N	25	57.935	W	80	49.226							2			20	
3A	N	25	52.131	W	80	48.406										20	
3A	N	25	59.141	W	80	48.784											20
3A	N	26	07.110	W	80	39		19									
3A	N	26	07.877	W	80	42.318					6	1	8			8	
3A	N	26	06.540	W	80	30		10		6							
3A	N	25	53.551	W	80	40.316		16									
3A	N	26	02.263	W	80	45.715	Mud Canal	15									
2B	N	26	11.130	W	80	22.084						15					
2A	N	26	15.599	W	80	25.068		14				1					
3A	N	25	57.938	W	80	44.234								5		9	1
3B	N	25	48.570	W	80	32		14									
3A	N	26	06.367	W	80	47.839		13									
3A	N	26	10.146	W	80	46		13									
3A	N	26	07.385	W	80	43.945			12								
3A	N	26	09.680	W	80	34.143		12									
3A	N	25	55.535	W	80	46.801							8			4	
3A	N	26	05.553	W	80	42.671							9			2	
3A	N	26	07.037	W	80	45.179						2	8				
3A	N	25	55.872	W	80	46.106								10			
3A	N	26	04.556	W	80	37.500										9	
3A	N	26	08.618	W	80	44.741		3	5					1			
3A	N	26	00.331	W	80	35.809		5			20	3					
3A	N	26	05.634	W	80	43.260		1	7								
3A	N	26	06.138	W	80	36.631								8			
3A	N	26	06.175	W	80	43.215						1		7			

3A	N	25	47.810	W	80	41	8				
3B	N	25	50.300	W	80	32	8				
3A	N	25	50.407	W	80	31.872	8	3			
3A	N	25	50.536	W	80	44.521				8	
3A	N	25	57.205	W	80	43.775	8				
3B	N	25	48.570	W	80	31.440	7				
3A	N	26	02.263	W	80	45.715	6				
2B	N	26	10.000	W	80	22.992			6		
3A	N	25	52.741	W	80	21.779	5	2	1		
3A	N	26	08.086	W	80	44.249				5	
2A	N	26	17.570	W	80	23.290	5				
3B	N	25	48.570	W	80	31.670	5				
3A	N	25	50.830	W	80	31.368	3		2		
3A	N	25	50.949	W	80	31.175	4		1		
3A	N	25	51.851	W	80	39.814	4	1	1		
3A	N	25	55.000	W	80	43	5				
3A	N	26	05.993	W	80	47.877	4				
3A	N	26	07.892	W	80	42.151	4	1			
3A	N	25	46.095	W	80	49.277			1		3
3B	N	25	50.870	W	80	31	4				
3A	N	25	52.788	W	80	43.510			4		
3A	N	25	54.881	W	80	43.350		8	4		
3A	N	25	54.899	W	80	46.433		2	4		
3A	N	26	02.343	W	80	38.394		2	3		
3A	N	26	09.500	W	80	37.630	3				
3A	N	25	46.108	W	80	41.264					3
3A	N	25	46.725	W	80	42.098		6	3		
3A	N	25	46.917	W	80	41.336	2		1		
3B	N	25	48.570	W	80	31.160	3				
3A	N	25	49.134	W	80	40.292		9	3		
3A	N	25	50.010	W	80	39.442	2	3	1		

3A	N	25	50.463	W	80	31.393	2	5	1	
3A	N	25	50.788	W	80	42.191		1	3	
3A	N	25	52.065	W	80	44.871			3	
3A	N	25	53.664	W	80	30.827	2	1	1	
3A	N	25	54.096	W	80	44.328			3	
3A	N	25	54.882	W	80	47.452			3	
3A	N	25	54.991	W	80	47.020		1	3	
3A	N	26	05.740	W	80	38.482			2	
3A	N	26	05.750	W	80	37.657				2
3A	N	26	06.626	W	80	37.627			1	1
2B	N	26	10.080	W	80	22.200			2	
2B	N	26	10.100	W	80	22.650			2	
3A	N	25	46.126	W	80	43.685		1	2	
3A	N	25	46.151	W	80	49.181			2	
3A	N	25	46.571	W	80	47.781		6	2	
3A	N	25	46.643	W	80	41.618		1	2	
3A	N	25	46.775	W	80	48.522			2	
3A	N	25	47.551	W	80	50.168			2	
3A	N	25	47.713	W	80	48.843			2	
3A	N	25	48.263	W	80	47.361			2	
3A	N	25	48.287	W	80	44.666		1	2	
3A	N	25	48.439	W	80	42.853			2	
3A	N	25	48.664	W	80	44.415			2	
3A	N	25	48.939	W	80	42.765			2	
3A	N	25	49.418	W	80	42.860			2	
3A	N	25	50.056	W	80	41.203		2	2	
3A	N	25	50.360	W	80	45.771			2	
3A	N	25	50.392	W	80	50.144			2	
3A	N	25	50.768	W	80	40.692		3	2	
3A	N	25	50.821	W	80	31.653	1	3	1	
3A	N	25	51.051	W	80	41.604		4	2	

3A	N	25	51.194	W	80	45.445		2	2
3A	N	25	51.509	W	80	47.589			2
3A	N	25	51.638	W	80	40.257			2
3A	N	25	51.809	W	80	39.717			2
3A	N	25	51.982	W	80	42.808			2
3A	N	25	52.137	W	80	39.618		3	2
3A	N	25	52.485	W	80	43.732			2
3A	N	25	52.488	W	80	31.450	1		1
3A	N	25	52.517	W	80	39.670		4	2
3A	N	25	52.748	W	80	42.595		3	2
3A	N	25	53.220	W	80	42.110		2	2
3A	N	25	53.589	W	80	40.607			2
3A	N	25	53.635	W	80	40.043		2	2
3A	N	25	53.721	W	80	39.766		7	2
3A	N	25	53.824	W	80	40.340			2
3A	N	25	53.829	W	80	42.252			2
3A	N	25	54.304	W	80	40.752		1	2
3A	N	25	54.691	W	80	47.385		5	2
3A	N	25	55.058	W	80	43.987			2
3A	N	25	55.225	W	80	43.379			2
3A	N	25	55.360	W	80	40.398			2
3A	N	25	56.445	W	80	46.223			2
3A	N	25	56.594	W	80	44.904			2
3A	N	25	56.623	W	80	44.920			2
3A	N	25	57.048	W	80	43.806		10	2
3A	N	25	57.089	W	80	40.074			2
3A	N	26	00.794	W	80	50.259			1
3A	N	26	00.986	W	80	33.421			1
3A	N	26	01.726	W	80	38.688			1
3A	N	26	02.093	W	80	50.260			1
3A	N	26	05.589	W	80	37.615			1

3A	N	26	07.187	W	80	38.372		1
3A	N	26	07.660	W	80	44.176		1
2B	N	26	10.251	W	80	22.757		1
2B	N	26	10.348	W	80	22.971		1
2B	N	26	11.448	W	80	21.964	1	1
3A	N	25	45.936	W	80	49.155		1
3A	N	25	46.157	W	80	41.959		1
3A	N	25	46.162	W	80	47.792		1
3A	N	25	46.210	W	80	47.554		1
3A	N	25	46.269	W	80	49.323		1
3A	N	25	46.283	W	80	47.497	7	1
3A	N	25	46.295	W	80	49.277		1
3A	N	25	46.326	W	80	47.461	3	1
3A	N	25	46.327	W	80	44.742		1
3A	N	25	46.345	W	80	41.829	5	1
3A	N	25	46.358	W	80	48.778		1
3A	N	25	46.381	W	80	43.875		1
3A	N	25	46.416	W	80	42.706		1
3A	N	25	46.482	W	80	49.750		1
3A	N	25	46.605	W	80	42.491		1
3A	N	26	46.691	W	80	49.966		1
3A	N	25	46.733	W	80	42.658	2	1
3A	N	25	46.766	W	80	48.643		1
3A	N	25	46.863	W	80	48.509		1
3A	N	25	46.923	W	80	43.493		1
3A	N	25	46.923	W	80	48.439		1
3A	N	25	46.971	W	80	45.164		1
3A	N	25	47.024	W	80	48.368	4	1
3A	N	25	47.058	W	80	43.898	1	1
3A	N	25	47.060	W	80	43.626		1
3A	N	25	47.208	W	80	43.876	3	1

3A	N	25	47.240	W	80	46.001		1
3A	N	25	47.243	W	80	48.559		1
3A	N	25	47.293	W	80	46.325		1
3A	N	25	47.438	W	80	48.924		1
3A	N	25	47.602	W	80	45.806		1
3A	N	25	47.617	W	80	43.750		1
3A	N	25	47.744	W	80	41.067		1
3B	N	25	47.856	W	80	35.265		1
3A	N	25	47.939	W	80	50.136		1
3A	N	25	48.127	W	80	44.181	2	1
3A	N	25	48.144	W	80	40.800		1
3A	N	25	48.180	W	80	45.211	2	1
3A	N	25	48.184	W	80	44.540		1
3A	N	25	48.187	W	80	45.894		1
3A	N	25	48.308	W	80	42.503		1
3A	N	25	48.371	W	80	40.762		1
3A	N	25	48.419	W	80	47.428		1
3A	N	25	48.535	W	80	48.477		1
3A	N	25	48.601	W	80	42.359	1	1
3A	N	25	48.641	W	80	48.482	1	1
3A	N	25	48.748	W	80	40.600	3	1
3A	N	25	48.932	W	80	46.307		1
3A	N	25	49.008	W	80	40.388	2	1
3A	N	25	49.022	W	80	29.965		1
3A	N	25	49.047	W	80	40.120	10	1
3A	N	25	49.139	W	80	40.267	2	1
3A	N	25	49.175	W	80	40.334		1
3A	N	25	49.234	W	80	42.442		1
3A	N	25	49.234	W	80	46.152	2	1
3A	N	25	49.240	W	80	42.430		1
3A	N	25	49.409	W	80	40.297	8	1

3A	N	25	49.555	W	80	40.307		1
3A	N	25	49.599	W	80	40.857		1
3A	N	25	49.704	W	80	40.551		1
3A	N	25	49.738	W	80	41.145		1
3A	N	25	49.741	W	80	39.797	4	1
3A	N	25	49.766	W	80	40.725	1	1
3A	N	25	49.839	W	80	45.004		1
3A	N	25	49.847	W	80	45.205	1	1
3A	N	25	49.996	W	80	30.251	2	1
3A	N	25	50.156	W	80	39.979		1
3A	N	25	50.381	W	80	42.243	2	1
3A	N	25	50.442	W	80	47.128		1
3A	N	25	50.450	W	80	31.668	4	1
3A	N	25	50.459	W	80	39.765	4	1
3A	N	25	50.561	W	80	43.409		1
3A	N	25	50.579	W	80	38.737	3	1
3A	N	25	50.706	W	80	43.275	1	1
3A	N	25	50.862	W	80	44.959	2	1
3A	N	25	51.010	W	80	42.323	2	1
3A	N	25	51.301	W	80	40.884	1	1
3A	N	25	51.594	W	80	44.701		1
3A	N	25	51.670	W	80	38.346	1	1
3A	N	25	51.730	W	80	45.248	1	1
3A	N	25	51.786	W	80	42.243		1
3A	N	25	51.860	W	80	45.020		1
3A	N	25	51.863	W	80	46.622	2	1
3A	N	25	51.872	W	80	45.008	3	1
3A	N	25	51.886	W	80	47.479		1
3A	N	25	52.308	W	80	39.575		1
3A	N	25	52.315	W	80	39.551		1
3A	N	25	52.404	W	80	39.015		1

3A	N	25	52.426	W	80	39.454	6	1
3A	N	25	52.460	W	80	47.472	1	1
3A	N	25	52.484	W	80	43.732	1	1
3A	N	25	52.507	W	80	44.122	1	1
3A	N	25	52.522	W	80	38.724		1
3A	N	25	52.556	W	80	38.700	1	1
3A	N	25	52.561	W	80	48.378		1
3A	N	25	52.595	W	80	48.384		1
3A	N	25	52.666	W	80	42.349	3	1
3A	N	25	52.682	W	80	42.843		1
3A	N	25	52.682	W	80	48.193		1
3A	N	25	52.683	W	80	45.477		1
3A	N	25	52.808	W	80	47.670		1
3A	N	25	52.994	W	80	38.223		1
3A	N	25	53.068	W	80	47.869		1
3A	N	25	53.124	W	80	48.203		1
3A	N	25	53.203	W	80	48.827		1
3A	N	25	53.230	W	80	46.875		1
3A	N	25	53.231	W	80	46.898		1
3A	N	25	53.253	W	80	48.296		1
3A	N	25	53.328	W	80	48.013		1
3A	N	25	53.536	W	80	47.621	2	1
3A	N	25	53.799	W	80	42.042		1
3A	N	25	54.233	W	80	42.485	1	1
3A	N	25	54.372	W	80	43.252	1	1
3A	N	25	54.477	W	80	39.670	2	1
3A	N	25	54.639	W	80	43.364		1
3A	N	25	54.639	W	80	43.394		1
3A	N	25	54.679	W	80	39.360		1
3A	N	25	54.772	W	80	40.096	1	1
3A	N	25	54.808	W	80	39.734	2	1

3A	N	25	54.818	W	80	39.362		1
3A	N	25	54.878	W	80	36.506		1
3A	N	25	55.036	W	80	42.667		1
3A	N	25	55.063	W	80	40.055		1
3A	N	25	55.237	W	80	43.370	2	1
3A	N	25	55.270	W	80	43.395	7	1
3A	N	25	55.338	W	80	39.744	1	1
3A	N	25	55.610	W	80	47.567		1
3A	N	25	55.692	W	80	46.728		1
3A	N	25	55.731	W	80	41.251	3	1
3A	N	25	55.757	W	80	45.078	7	1
3A	N	25	55.819	W	80	40.778	2	1
3A	N	25	55.919	W	80	40.567	6	1
3A	N	25	56.057	W	80	39.227	4	1
3A	N	25	56.212	W	80	38.992	1	1
3A	N	25	56.259	W	80	43.107		1
3A	N	25	56.289	W	80	38.591		1
3A	N	25	56.389	W	80	44.522		1
3A	N	25	56.400	W	80	42.444	4	1
3A	N	25	56.415	W	80	40.854		1
3A	N	25	56.467	W	80	39.864	4	1
3A	N	25	56.531	W	80	41.375	3	1
3A	N	25	56.539	W	80	40.807		1
3A	N	25	56.677	W	80	41.184	1	1
3A	N	25	56.716	W	80	40.450		1
3A	N	25	56.772	W	80	41.242		1
3A	N	25	56.777	W	80	37.924	2	1
3A	N	25	56.894	W	80	45.519	1	1
3A	N	25	56.937	W	80	44.422	1	1
3A	N	25	56.952	W	80	39.330		1
3A	N	25	57.101	W	80	41.662		1

3A	N	25	57.118	W	80	42.161			1
3A	N	25	57.125	W	80	42.023		3	1
3A	N	25	57.197	W	80	45.070			1
3A	N	25	57.200	W	80	43.70			1
3A	N	25	57.242	W	80	40.217			1
3A	N	25	57.299	W	80	41.075			1
3A	N	25	57.355	W	80	46.372			1
3A	N	25	57.375	W	80	45.187		1	1
3A	N	25	57.377	W	80	40.801		2	1
3A	N	25	57.453	W	80	43.192			1
3A	N	25	57.472	W	80	48.298			1
3A	N	25	57.490	W	80	43.404	1		
3A	N	25	57.513	W	80	49.122			1
3A	N	25	58.136	W	80	44.707		4	1
3A	N	25	58.184	W	80	46.847			1
3A	N	25	58.539	W	80	37.533		6	1
3A	N	25	59.598	W	80	39.885			1
3A	N	25	59.697	W	80	44.779			1
3A	N	26	07.636	W	80	44.719		1	
3B	N	25	45.790	W	80	33.688		4	
3B	N	25	45.830	W	80	33.691		1	
3B	N	25	45.850	W	80	33.691		2	
3A	N	25	46.129	W	80	48.083		1	
3A	N	25	46.135	W	80	31.781		1	
3A	N	25	46.141	W	80	31.782		4	
3A	N	25	46.157	W	80	40.701		2	
3A	N	25	46.183	W	80	31.783		1	
3A	N	25	46.292	W	80	43.827		6	
3A	N	25	46.296	W	80	31.786		1	
3A	N	25	46.351	W	80	43.702		2	
3A	N	25	46.514	W	80	47.625		1	

3A	N	25	46.662	W	80	46.300	1
3A	N	25	46.683	W	80	42.622	2
3B	N	25	46.724	W	80	33.707	1
3A	N	25	46.772	W	80	42.891	1
3A	N	25	47.043	W	80	45.555	1
3A	N	25	47.093	W	80	46.348	1
3A	N	25	47.097	W	80	41.857	2
3A	N	25	47.100	W	80	43.662	8
3B	N	25	47.120	W	80	33.688	1
3A	N	25	47.336	W	80	41.821	1
3A	N	25	47.338	W	80	42.600	1
3B	N	25	47.442	W	80	33.706	1
3A	N	25	47.521	W	80	40.663	2
3A	N	25	47.601	W	80	43.892	1
3B	N	25	47.862	W	80	37.327	1
3A	N	25	48.065	W	80	48.237	5
3A	N	25	48.271	W	80	42.532	1
3A	N	25	48.339	W	80	42.163	1
3A	N	25	48.385	W	80	41.277	1
3A	N	25	48.391	W	80	47.790	1
3A	N	25	48.423	W	80	42.617	1
3A	N	25	48.581	W	80	40.753	4
3A	N	25	48.620	W	80	48.491	1
3A	N	25	48.630	W	80	43.291	4
3A	N	25	48.682	W	80	42.546	1
3A	N	25	48.744	W	80	41.259	1
3A	N	25	49.029	W	80	46.364	6
3A	N	25	49.056	W	80	41.239	1
3A	N	25	49.314	W	80	42.560	1
3A	N	25	49.425	W	80	39.239	1
3A	N	25	49.474	W	80	39.674	1

3A	N	25	49.545	W	80	39.339	1
3A	N	25	49.582	W	80	40.212	2
3A	N	25	49.609	W	80	40.147	2
3A	N	25	49.780	W	80	40.704	3
3A	N	25	49.903	W	80	40.394	1
3A	N	25	50.126	W	80	41.125	6
3A	N	25	50.175	W	80	45.337	3
3A	N	25	50.253	W	80	41.137	1
3A	N	25	50.360	W	80	31.260	4
3A	N	25	50.411	W	80	42.188	1
3A	N	25	50.630	W	80	42.724	1
3A	N	25	50.792	W	80	40.239	1
3A	N	25	51.305	W	80	39.801	1
3A	N	25	51.314	W	80	38.440	5
3A	N	25	51.434	W	80	42.515	1
3A	N	25	51.585	W	80	42.807	3
3A	N	25	51.640	W	80	39.933	1
3A	N	25	51.698	W	80	42.628	2
3A	N	25	51.819	W	80	42.350	7
3A	N	25	51.837	W	80	39.297	1
3A	N	25	52.371	W	80	37.936	2
3A	N	25	52.477	W	80	48.125	4
3A	N	25	52.521	W	80	45.331	1
3A	N	25	52.937	W	80	43.487	1
3A	N	25	53.129	W	80	40.001	1
3A	N	25	53.630	W	80	44.637	1
3A	N	25	53.762	W	80	41.709	1
3A	N	25	54.003	W	80	39.232	1
3A	N	25	54.110	W	80	39.490	1
3A	N	25	54.309	W	80	45.291	2
3A	N	25	54.354	W	80	43.795	1

3A	N	25	54.406	W	80	39.854	1
3A	N	25	54.424	W	80	43.851	1
3A	N	25	54.476	W	80	42.266	3
3A	N	25	54.603	W	80	44.835	1
3A	N	25	54.661	W	80	38.525	1
3A	N	25	54.859	W	80	44.046	8
3A	N	25	55.088	W	80	46.423	1
3A	N	25	55.274	W	80	43.423	5
3A	N	25	55.291	W	80	44.977	1
3A	N	25	55.823	W	80	38.795	1
3A	N	25	55.898	W	80	44.365	3
3A	N	25	55.987	W	80	45.500	1
3A	N	25	55.996	W	80	37.168	1
3A	N	25	56.007	W	80	42.851	1
3A	N	25	56.364	W	80	44.755	6
3A	N	25	56.369	W	80	44.750	3
3A	N	25	56.387	W	80	39.354	1
3A	N	25	56.536	W	80	44.834	2
3A	N	25	56.542	W	80	44.260	1
3A	N	25	56.589	W	80	40.001	4
3A	N	25	56.598	W	80	40.974	1
3A	N	25	56.947	W	80	39.078	1
3A	N	25	57.035	W	80	40.155	10
3A	N	25	57.040	W	80	43.777	2
3A	N	25	57.111	W	80	38.844	2
3A	N	25	57.243	W	80	39.243	2
3A	N	25	57.317	W	80	46.370	2
3A	N	25	57.803	W	80	36.380	1
3A	N	25	58.486	W	80	43.465	3
3A	N	25	58.809	W	80	41.737	6

Total, WCAs 2 & 3	5,053	19,955	267	1,121	390	1,947	436	2,997	545	20	21	15

Appendix 1.2. Numbers of nests by species and colony in WCA 1 (Loxahatchee NWR) of the Everglades, 2004.

Area	Latitude			Longitude			Colony	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLI
LOX	N	26	26.250	W	80	15	Lox 70		8,000										
LOX	N	26	26.350	W	80	24	Lox 99	220	1,000										
LOX	N	26	27.523	W	80	14.395		300	350		200		25	10	50	40			20
LOX	N	26	28.130	W	80	22.324		300			50			30					
LOX	N	26	31.338	W	80	15.814		25	100	4	35		30	11	125	7			22
LOX	N	26	27.450	W	80	14		300											
LOX	N	26	22.960	W	80	15		259											
LOX	N	26	33.580	W	80	15	Canal North		250										
LOX	N	26	31.910	W	80	17.693		32					25	4		60			
LOX	N	26	27.439	W	80	21.244		20			4		2	3		90			
LOX	N	26	27.009	W	80	15.798					1		12			100			
LOX	N	26	33.225	W	80	15.058		80		20									
LOX	N	26	22.310	W	80	19		95											
LOX	N	26	33.041	W	80	15.012		90											
LOX	N	26	27.751	W	80	22.358					42					87			
LOX	N	26	31.174	W	80	19.135								2	2	80			
LOX	N	25	59.791	W	80	39.507					20	1		35		45			
LOX	N	26	22.181	W	80	15.475		80											
LOX	N	26	26.842	W	80	16.537		5								75			
LOX	N	26	29.528	W	80	22.339							80						
LOX	N	26	31.855	W	80	17.687							5	1	12	54			
LOX	N	26	29.536	W	80	22.353					3		5			60			
LOX	N	26	22.400	W	80	16		60											
LOX	N	26	22.800	W	80	15		60											
LOX	N	25	58.237	W	80	42.031		55			6	1							
LOX	N	26	23.860	W	80	15		55											
LOX	N	26	31.861	W	80	17.702							4		12	36			
LOX	N	26	32.999	W	80	15.088		50			22	2							
LOX	N	26	22.650	W	80	16		50											
LOX	N	26	27.347	W	80	21.243		5			6		5	8		30			
LOX	N	26	29.588	W	80	16.482										45			
LOX	N	26	31.927	W	80	17.661		2			2		3	1	24	11			

LOX	N	26	32.161	W	80	17.817							41	
LOX	N	26	32.161	W	80	17.817							41	
LOX	N	26	32.349	W	80	16.120							41	
LOX	N	26	22.960	W	80	15	40							
LOX	N	26	31.640	W	80	26	40							
LOX	N	26	28.896	W	80	14.507				3		2	5	29
LOX	N	26	33.204	W	80	15.117	37	5	2					
LOX	N	26	31.877	W	80	17.645						10	24	
LOX	N	26	30.602	W	80	19.446		1					30	
LOX	N	26	31.572	W	80	19.146							29	
LOX	N	26	33.433	W	80	15.385	26		1					
LOX	N	26	23.871	W	80	18.724	1						25	
LOX	N	26	26.774	W	80	15.450	20				5			
LOX	N	26	28.811	W	80	14.527		1		4			2	15
LOX	N	26	33.443	W	80	15.510	20	1	1					
LOX	N	26	00.480	W	80	39.859					5		15	
LOX	N	26	28.153	W	80	15.170							19	
LOX	N	26	30.585	W	80	19.407		1					17	
LOX	N	26	33.470	W	80	16.034			1		16			
LOX	N	26	29.717	W	80	15.168		12	1		5		10	
LOX	N	26	31.716	W	80	16.080					16			
LOX	N	26	33.475	W	80	15.397	15	3	1					
LOX	N	26	29.336	W	80	15.949					15			
LOX	N	26	32.371	W	80	16.046							15	
LOX	N	25	59.266	W	80	42.423		3			15			
LOX	N	26	28.613	W	80	22.665					14			
LOX	N	26	33.528	W	80	15.697	10	7	2		1			
LOX	N	26	33.529	W	80	15.431	12	6	1					
LOX	N	26	28.100	W	80	25	12							
LOX	N	26	33.207	W	80	15.853	5		2		5			
LOX	N	26	32.084	W	80	17.517					11			
LOX	N	26	26.658	W	80	15.425	10							
LOX	N	26	29.460	W	80	16.033			2		8			
LOX	N	26	27.822	W	80	14.737				9				
LOX	N	26	31.871	W	80	17.715		2				4	5	

LOX	N	26	33.438	W	80	15.445	8		2	1				
LOX	N	26	29.432	W	80	22.777					8			
LOX	N	26	32.187	W	80	15.569							8	
LOX	N	25	58.771	W	80	39.290	2		5	1		4		
LOX	N	25	59.616	W	80	42.550						7		
LOX	N	26	22.149	W	80	17.263					6			
LOX	N	26	22.475	W	80	17.672				6				
LOX	N	26	26.843	W	80	14.759			1	6				
LOX	N	26	27.655	W	80	14.563					1		5	
LOX	N	26	28.884	W	80	14.466								6
LOX	N	26	29.207	W	80	22.719					1	5		
LOX	N	26	32.100	W	80	17.690						2	4	
LOX	N	26	32.100	W	80	17.690						2	4	
LOX	N	26	32.291	W	80	14.579						6		
LOX	N	26	35.924	W	80	17.464						1	5	
LOX	N	25	58.190	W	80	39.485			4	1		5		
LOX	N	26	22.480	W	80	17.700				5				
LOX	N	26	27.003	W	80	14.403				5				
LOX	N	26	29.347	W	80	15.978					3		2	
LOX	N	26	33.454	W	80	15.515	4		5	1				
LOX	N	26	34.237	W	80	17.195				2	2	1		
LOX	N	25	58.716	W	80	39.435	2		5			3		
LOX	N	26	22.169	W	80	17.153			1		1		3	
LOX	N	26	25.050	W	80	15.494		4						
LOX	N	26	27.400	W	80	25	4							
LOX	N	26	34.165	W	80	17.283							4	
LOX	N	26	35.123	W	80	17.010						4		
LOX	N	26	26.306	W	80	17.324				3				
LOX	N	26	26.437	W	80	14.301				3				
LOX	N	26	28.372	W	80	16.325				3				
LOX	N	26	28.605	W	80	15.713				3				
LOX	N	26	30.744	W	80	15.425						3		
LOX	N	26	30.782	W	80	17.070						3		
LOX	N	26	31.774	W	80	14.900						3		
LOX	N	26	32.571	W	80	14.593			2	2			1	

LOX	N	26	32.724	W	80	14.619			2	3	
LOX	N	26	33.447	W	80	16.623					3
LOX	N	26	33.466	W	80	17.048				3	
LOX	N	26	25.688	W	80	14.741				2	
LOX	N	26	26.491	W	80	16.114				2	
LOX	N	26	26.762	W	80	14.691				2	
LOX	N	26	26.939	W	80	14.566	2				
LOX	N	26	27.149	W	80	15.708				2	
LOX	N	26	27.157	W	80	15.654			2	2	
LOX	N	26	27.377	W	80	16.448				2	
LOX	N	26	27.640	W	80	14.756				2	
LOX	N	26	27.694	W	80	14.537				2	
LOX	N	26	27.834	W	80	14.526				2	
LOX	N	26	28.330	W	80	22.876				2	
LOX	N	26	28.574	W	80	17.402			4	2	
LOX	N	26	28.690	W	80	15.799				2	
LOX	N	26	28.976	W	80	14.892				2	
LOX	N	26	30.179	W	80	23.051				2	
LOX	N	26	30.906	W	80	16.223			5	1	1
LOX	N	26	31.153	W	80	15.714				2	
LOX	N	26	31.757	W	80	14		2			
LOX	N	26	32.059	W	80	16.538				2	
LOX	N	26	33.337	W	80	15.426				2	
LOX	N	25	58.074	W	80	39.376			3	2	
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LOX	N	26	22.104	W	80	17.254			10	1	
LOX	N	26	22.132	W	80	17.613				1	
LOX	N	26	23.915	W	80	16.865				1	
LOX	N	26	23.927	W	80	16.911				1	
LOX	N	26	23.938	W	80	16.926				1	
LOX	N	26	24.088	W	80	16.271				1	
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LOX	N	26	24.114	W	80	16.197				1	
LOX	N	26	24.165	W	80	16.486				1	
LOX	N	26	24.255	W	80	16.121				1	

LOX	N	26	24.439	W	80	16.181			1
LOX	N	26	24.500	W	80	16.073			1
LOX	N	26	24.757	W	80	18.701		1	1
LOX	N	26	24.774	W	80	18.430			1
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LOX	N	26	25.188	W	80	15.543			1
LOX	N	26	25.195	W	80	15.439			1
LOX	N	26	25.474	W	80	15.342			1
LOX	N	26	25.557	W	80	18.089		1	1
LOX	N	26	25.579	W	80	16.342			1
LOX	N	26	25.580	W	80	14.822			1
LOX	N	26	25.632	W	80	18.477			1
LOX	N	26	25.647	W	80	15.209			1
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LOX	N	26	25.857	W	80	17.617			1
LOX	N	26	25.872	W	80	18.815			1
LOX	N	26	25.911	W	80	18.460			1
LOX	N	26	25.961	W	80	17.464			1
LOX	N	26	25.995	W	80	17.585			1
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LOX	N	26	26.070	W	80	17.702			1
LOX	N	26	26.226	W	80	17.074			1
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LOX	N	26	26.462	W	80	17.178			1
LOX	N	26	26.499	W	80	16.074		1	1
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LOX	N	26	26.616	W	80	14.434			1
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LOX	N	26	26.703	W	80	15.510	1	2	

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LOX	N	26	26.830	W	80	22.687		1
LOX	N	26	26.852	W	80	16.392		1
LOX	N	26	26.887	W	80	14.731		1
LOX	N	26	26.939	W	80	14.566	21	1
LOX	N	26	26.968	W	80	14.610	1	1
LOX	N	26	27.092	w	80	16.509		1
LOX	N	26	27.241	W	80	15.339		1
LOX	N	26	27.256	W	80	15.314		1
LOX	N	26	27.402	W	80	15.224	1	1
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LOX	N	26	28.397	W	80	16.131		1
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LOX	N	26	29.896	W	80	16.278		1
LOX	N	26	29.928	W	80	21.640		1
LOX	N	26	30.088	W	80	17.477		1

LOX	N	26	30.143	W	80	22.552			1
LOX	N	26	30.206	W	80	16.532			1
LOX	N	26	30.244	W	80	14.484			1
LOX	N	26	30.287	W	80	19.318			1
LOX	N	26	30.299	W	80	18.223			1
LOX	N	26	30.350	W	80	17.577			1
LOX	N	26	30.375	W	80	14.485			1
LOX	N	26	30.404	W	80	18.197			1
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LOX	N	26	30.462	W	80	18.625			1
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LOX	N	26	30.556	W	80	18.078			1
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LOX	N	26	30.609	W	80	19.102			1
LOX	N	26	30.623	W	80	17.418			1
LOX	N	26	30.674	W	80	17.504		2	1
LOX	N	26	30.852	W	80	16.142			1
LOX	N	26	30.910	W	80	19.791			1
LOX	N	26	30.931	W	80	19.517			1
LOX	N	26	30.959	W	80	15.554			1
LOX	N	26	31.009	W	80	19.080			1
LOX	N	26	31.131	W	80	19.948			1
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LOX	N	26	31.272	W	80	19.504			1
LOX	N	26	31.280	W	80	16.712			1
LOX	N	26	31.417	W	80	14.715			1
LOX	N	26	31.432	W	80	16.788			1
LOX	N	26	31.470	W	80	14	1		
LOX	N	26	31.475	W	80	16.527			1
LOX	N	26	31.720	W	80	16.700			1
LOX	N	26	31.725	W	80	16.089			1
LOX	N	26	31.959	W	80	15.167			1
LOX	N	26	32.019	W	80	16.637			1

LOX	N	26	32.664	W	80	14.794		1
LOX	N	26	33.029	W	80	16.704		1
LOX	N	26	33.357	W	80	16.330		1
LOX	N	26	33.603	W	80	17.158		1
LOX	N	26	33.865	W	80	17.312		1
LOX	N	26	33.921	W	80	17.497		1
LOX	N	26	33.928	W	80	17.098		1
LOX	N	26	34.100	W	80	16.172		1
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LOX	N	26	34.240	W	80	16.685		1
LOX	N	26	34.943	W	80	17.239		1
LOX	N	26	35.201	W	80	17.109		1
LOX	N	26	35.299	W	80	16.992		1
LOX	N	25	57.906	W	80	38.956	8	1
LOX	N	25	58.326	W	80	39.658		1
LOX	N	25	59.049	W	80	39.989		1
LOX	N	25	59.198	W	80	39.332		1
LOX	N	25	59.596	W	80	39.898	1	1
LOX	N	26	22.107	W	80	17.270	2	
LOX	N	26	22.132	W	80	17.817	4	
LOX	N	26	22.142	W	80	17.782	2	
LOX	N	26	22.195	W	80	17.700	3	
LOX	N	26	23.956	W	80	16.878	1	
LOX	N	26	24.604	W	80	16.125	1	
LOX	N	26	24.771	W	80	16.599	1	
LOX	N	26	24.830	W	80	17.125	1	
LOX	N	26	25.745	W	80	16.247	2	
LOX	N	26	26.702	W	80	15.439	2	
LOX	N	26	26.713	W	80	15.500	3	
LOX	N	26	26.715	W	80	15.466	4	
LOX	N	26	26.797	W	80	15.474	3	
LOX	N	26	26.803	W	80	14.723	1	
LOX	N	26	26.806	W	80	14.792	9	
LOX	N	26	26.830	W	80	15.444	2	
LOX	N	26	26.853	W	80	15.659	1	

LOX	N	26	26.915	W	80	14.695				3								
LOX	N	26	27.016	W	80	14.537				2								
LOX	N	26	27.087	W	80	15.723				1								
LOX	N	26	27.107	W	80	14.446				1								
LOX	N	26	27.116	W	80	15.727				1								
LOX	N	26	27.177	W	80	16.992				1								
LOX	N	26	27.214	W	80	16.972				2								
LOX	N	26	27.444	W	80	14.566				4								
LOX	N	26	27.446	W	80	15.781				1								
LOX	N	26	27.458	W	80	14.539				14								
LOX	N	26	27.466	W	80	14.531				7								
LOX	N	26	27.566	W	80	21.222				6								
LOX	N	26	27.620	W	80	21.206				1								
LOX	N	26	27.628	W	80	14.543				1								
LOX	N	26	27.639	W	80	14.713				12								
LOX	N	26	28.300	W	80	17.741				1								
LOX	N	26	28.418	W	80	17.126				1								
LOX	N	26	28.559	W	80	17.422				1								
LOX	N	26	29.031	W	80	21.777				1								
LOX	N	26	29.296	W	80	21.793				3								
LOX	N	26	30.599	W	80	19.441				1								
LOX	N	26	30.630	W	80	18.238												
LOX	N	26	30.784	W	80	22.327				1								
LOX	N	26	30.790	W	80	16.189				2								
LOX	N	26	31.019	W	80	20.716				1								
LOX	N	26	31.672	W	80	19.345				1								
LOX	N	26	31.703	W	80	19.289				1								
LOX	N	26	34.454	W	80	16.536				1								
LOX	N	25	58.385	W	80	39.249				3								
	total, Loxahatchee National Wildife Refuge						2,414	9,704	27	650	235	234	274	241	1,175	0	0	92

NESTING BY WADING BIRDS IN THE CENTRAL EVERGLADES, AND REPRODUCTIVE SUCCESS OF WOOD STORKS, 2005.

Executive Summary

Wading bird nesting responses (timing, location, numbers of nests) are an important variable in evaluating the success of the Comprehensive Everglades Restoration Plan (CERP). This study reports on nesting in the Water Conservation Areas (WCAs) of the Everglades during 2006. Not all species of wading birds are considered of equal importance in monitoring the success of CERP, and the focus is now on large white species, especially Wood Storks, White Ibises, Snowy Egrets, and Roseate Spoonbills.

In general, early nesting conditions in the winter/spring of 2004/5 were excellent with relatively high water levels in all pools, and rapid to very rapid drying throughout the system, November through February. This was probably one of the factors that led to large numbers of adult birds in the Everglades during February (20% more than the similar figure preceding the banner 2002 nesting season). However, in late February and throughout March, unseasonable rainfall and rising water levels resulted in widespread abandonments of nearly all species. Nest success was zero in many colonies (all nests failed), and we found no colonies or species in which nest success was greater than 10%. On the whole, however, numbers of nesting attempts remained well above the average of the past ten years, despite the poor late season nesting conditions. This seems to confirm a persisent increase in the numbers of birds nesting, beginning in the late 1990s.

Combining all species at all colonies in LNWR, WCA 2, and WCA 3, we estimated a grand total of 24,249 nests of wading birds (Cattle Egrets, Anhingas and cormorants excluded) were initiated (laid eggs) between February and July of 2005 in the WCAs. This figure could be an underestimate compared with recent years simply because we did not perform the same level of effort in ground surveys as previously. However, the bias towards underestimation is least serious for white-colored species and strongest for dark-colored species. Ground based surveys in the past have contributed an average of 30% of the total numbers of nesting attempts. Using the grand total of 24,248, the size of the nesting aggregation in 2005 in the WCAs and LNWR combined was slightly under 100% of the average of the past ten years, 61% of the average of the last five years, and about 40% of the recent high of 2002. Numbers of Great Egret nests were 52% the average of the last five years, and 68% of the average of the last ten. In 2004, Wood Stork nests in the central Everglades were very much reduced, with only 20 pairs attempting to nest in the WCAs. White Ibis nests were 71% of the average of the last five and 130% the average of the last ten years. Compared with the banner year of 2002, only half the ibis pairs (50.7%) nested in 2005. On the same individually identifiable ground survey transects, we found 1.2 times the number of Tricolored Herons as in 2004, 1.3 times the Great Blue Herons, 2.4 times the Anhingas, and 0.9 times the Little Blue Herons. If this survey can be taken as an honest indicator of nesting in the larger Everglades, it does not seem as though the dark-colored species that nest in small colonies experienced as much of a decline as the white-colored species nesting in large colonies. This fits with a general pattern of dark-colored species doing well in wet springs, and white-colored species doing poorly, that has been seen during the middle 1990's.

In terms of total numbers, the 2005 nesting event in the WCAs can be considered a considerable reduction from the very large and increasing numbers seen in 1999 – 2004. While this numerical reduction seems like a change from the increasing trend of nesting numbers, it should be remembered that the 2005 nesting response was quite large given the deep and rising water level conditions that

prevailed during the most important part of the nesting season.

In general, nesting success (probability of a nest raising one or more young to fledging age) was very low this year, with nearly all colonies experiencing abandonment of the majority of nests at some point during the season. This was true for Great Egrets, White Ibises, Wood Storks, and Snowy Egrets at the very least, and the trend was seen throughout the WCAs, Everglades National Park mainland, and Florida Bay. Most abandonment occurred during March, when water levels rose due to unseasonable rainfall. In the WCAs, we found no estimates of nest success greater than 10% in any colony.

Weather and water conditions during 2005

Temperatures

The winter and spring of 2005 were not particularly cold or hot by the standards of long term records – and were not characterized by extreme freezes (Figure 1.12). Although the data below are from a single station, this is adequate for detecting extreme temperature changes, particularly for those which occur at large geographic scales.

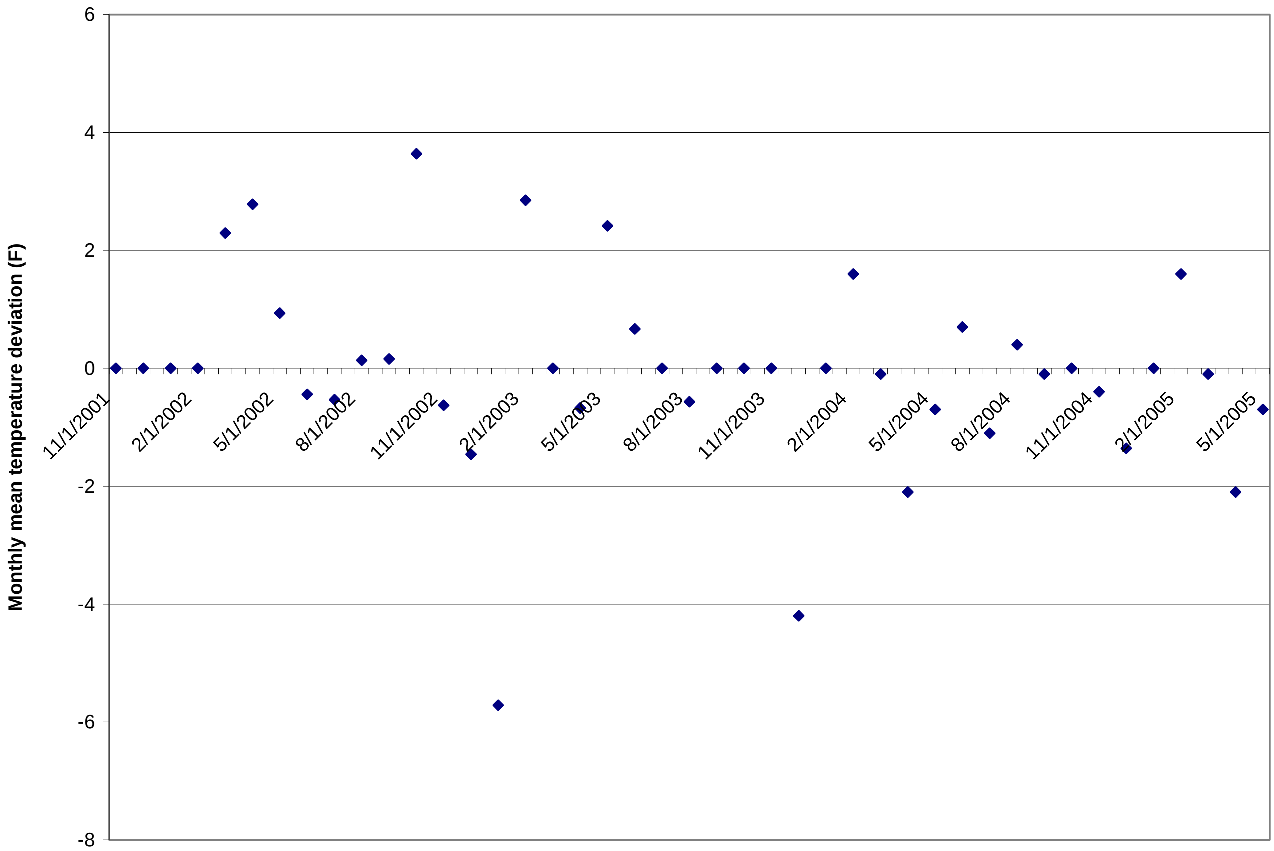

Figure 1.12. Mean monthly temperature at Tamiami Trail Ranger Station (40-mile bend), 2001 – 2005. Zero line indicates the monthly mean for the period of record, dots are the actual deviations from the mean in each month**.**

Rainfall

The rainy season of 2004 was characterized by very low rainfall in June, followed by large amounts of rain in August, mostly from tropical storms and hurricanes. This left the system fairly full by the time of nesting. The spring was rainier than usual (Figure 1.13) with rainfall totals in January at or close to one standard deviation in excess of the monthly mean, and well in excess of that in February. The winter/spring rainfall events were spaced closely enough that nesting cohorts that abandoned in response to one also experienced the next if they renested.

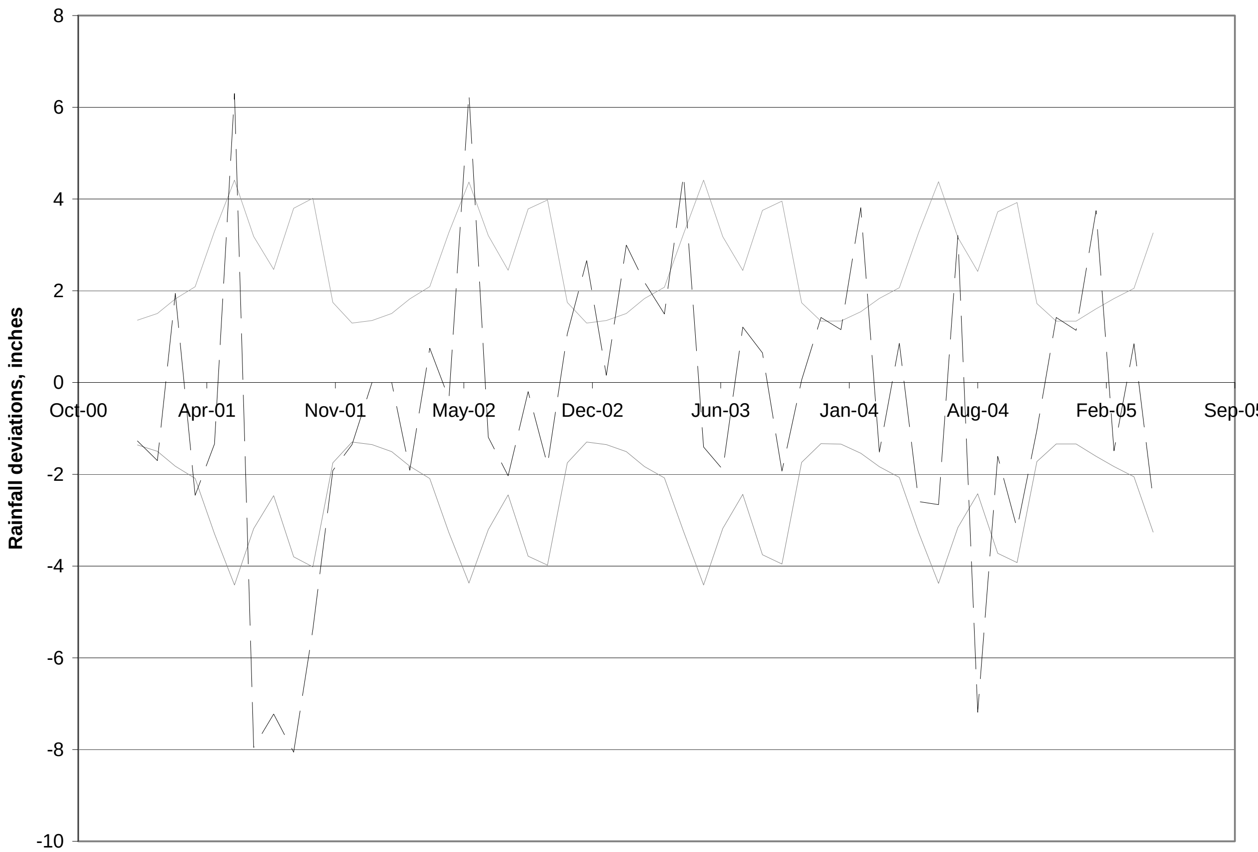

Figure 1.13. Deviations from mean monthly rainfall at Tamiami Trail Ranger Station (40-mile bend), 2000 – 2005. Zero line indicates the mean monthly rainfall, solid fluctuating lines are one standard deviation in excess or deficit of the mean deviations, and dotted line is actual deviations measured in each month.

Hydrology

In general, the water year in the central and southern Everglades preceding the nesting season was a relatively wet one, with water levels by November being high to very high (WCA 2A) by November (Figure 1.14). This was followed by a remarkably constant drying trend (November through early January). However, a series of unseasonably high rainfall events in late February and early March forced a reversal in this drying trend, which led to rising water levels in much of March. For example, at the Alley North colony in northern WCA 3A-North, water levels rose by over 30 cm in March (Figure 1.15), and by over 20 cm in Loxahatchee (Figure 1.16). This is a time when water levels are falling fast in more typical years. No significant drying was seen until the second week in April, at which point much of the nesting had been abandoned.

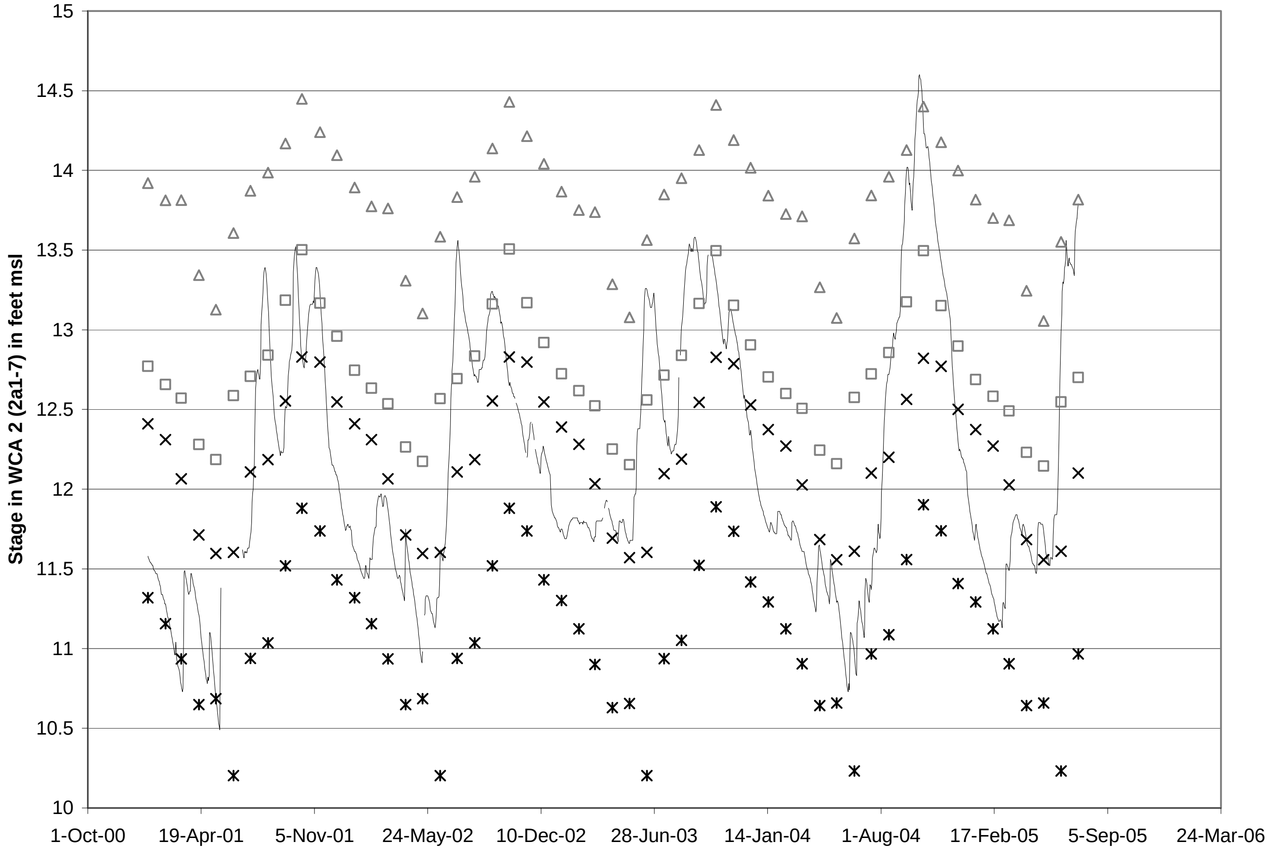

Figure1.15. Stage at 2A-17 Gauge in WCA 2A, 2000 – 2005. Solid line indicates actual stage, squares are mean monthly maximum stage for the period of record, x's are mean monthly minimum stage for POR, triangles are one standard deviation in excess of the mean maximum and asterisks are one standard deviation below the mean monthly minimums.

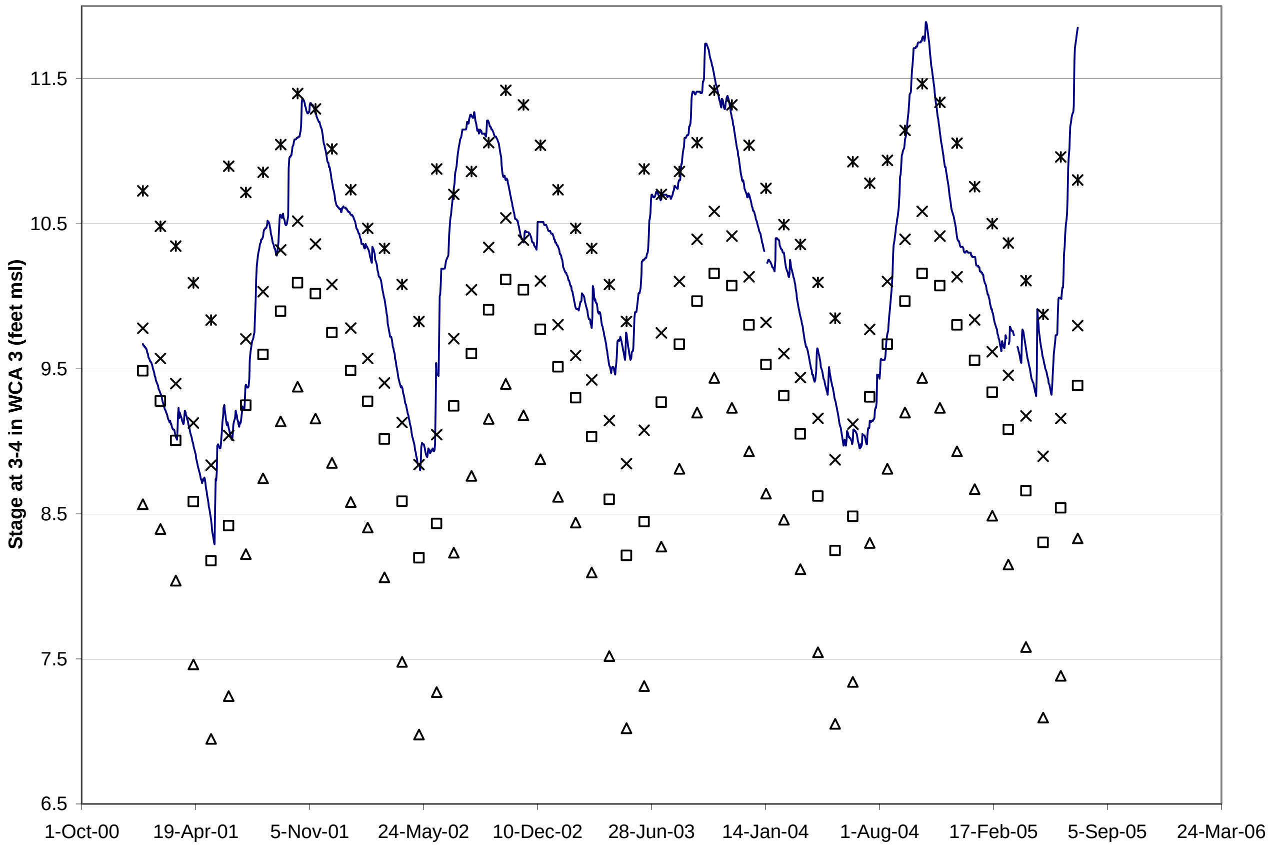

Figure 1.15. Stage at 3-4 Gauge in WCA 3, 2000 – 2005. Solid line indicates actual stage, x's are mean monthly maximum stage for the period of record, squares are mean monthly minimum stage for POR, asterisks are one standard deviation in excess of the mean maximum and triangles are one standard deviation below the mean monthly minimums.

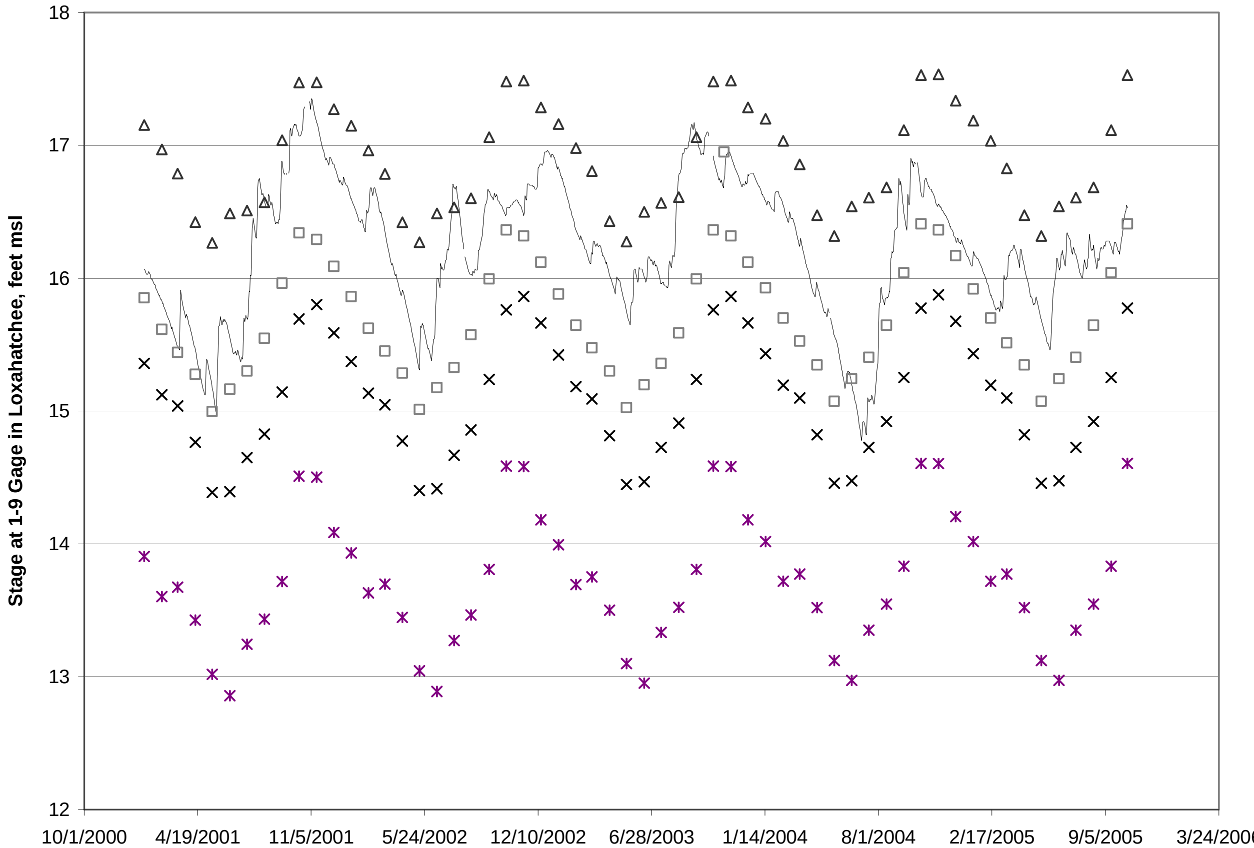

Figure 1.16. Stage at 1-9 gauge in Loxahatchee National Wildlife Refuge (WCA 1), 2000 – 2005. Solid line indicates actual stage, squares are mean monthly maximum stage for the period of record, x's are mean monthly minimum stage for POR, triangles are one standard deviation in excess of the mean maximum and asterisks are one standard deviation below the mean monthly minimums.

In the past, the behavior and reproductive response of birds has been thought to be predicted in part by the rate at which surface water recedes during the dry season (Kushlan et al. 1975, Frederick and Collopy 1989), as a result of both drainage and evapotranspiration. The mechanism of influence on the birds is through the concentration of prey animals on the marsh surface by the action of decreasing depths. This has been expressed as an early season recession rate (difference between monthly highs of November and January expressed as a per day rate) and a "late" recession rate (difference between monthly highs of January and March expressed as a per day rate). Note that a "fast" recession rate would be a high positive number, signifying rapid recession (2 mm/d and above), and a "slow" rate could be represented by negative numbers (stage actually increased between the two months).

Drying rates in 2005 were uniformly rapid (Table 1.6) during November through January, with recession rates between 5 and 9 mm/day (greater than 90th percentile for all WCAs). These uniformly rapid recession rates were then interrupted by heavy rainfall in February and March, and late drying rates (January through March) were very slow (60th, 10th, and 90th percentiles in WCA 3, 2, and 1 respectively). When both early and late drying rates are combined, WCAs 3, 1, and 2 fell into the 60th, tenth, and 90th percentiles, respectively.

Table 1.6. Water level recession rates (mm/d) in the Water Conservation Areas, with comparisons of the year in question with historical records at each station. Note that negative values indicate rising water, positive values indicate falling water. Percent exceedance refers to the percent of years in the record in which the drying rate is less than that of the current year.

Year	Station	Early Dry	Late Dry	% Exceedance Early Drying Rate*	% Exceedance Late Drying Rate*	% Exceedance Both Early and Late Drying Rate*
2005	3-4	4.9	2.6	90	60	60
2005	1-9	8.5	-0.1	100	10	10
2005	2A 1-7	9.3	5.5	90	90	90
2004	3-4	5.18	2.19	90.2	53.7	53.7
2004	1-9	1.46	1.27	36.8	36.8	7.9
2004	2A 1-7	6.80	3.98	90.7	90.7	86.0
2003	3-4	0.400	1.524	22.5	37.5	20
2003	1-9	-3.690	2.573	2.7	62.2	0
2003	2A 1-7	3.146	1.559	69.0	50.0	33.3
2002	3-4	4.001	1.96	75.6	48.6	43.2
2002	1-9	9.26	1.54	0.975	47.5	45
2002	2A 1-7	3.27	0.723	0.806	22.2	16.7
2001	3-4	3.098	2.43	55.6	61.1	33.3
2001	1-9	4.347	1.16	91.4	28.6	22.9
2001	2A 1-7	6.246	2.32	92.3	94.9	89.7
2000	3-4	7.935	7.70	100	100	100
2000	1-9	4.54	na	94.1	na	Na
2000	2A 1-7	7.595	5.57	94.5	94.8	89.7
1999	3-4	2.13	3.83	41.7	91.7	38.9
1999	1-9	2.19	4.24	18	29	14
1999	2A 1-7	7.77	7.46	97.2	94.5	97.1
1998	3-4	-0.60	0.11	4.88	21.92	0.00
1998	1-9	1.48	-0.52	34.3	2.85	0
1998	2A 1-7	-4	-0.04	2.9	20	0
1997	3-4	2.63	1.419	57	42	36
1997	1-9	2.19	0.581	51.5	15.2	3.03
1997	2A 1-7	4.12	2.77	94.1	73.5	70.5
1996	3-4	6.99	5.68	100	100	100
1996	1-9	0.14	0.383	25.0	3.5	0.0
1996	2A 1-7	11.50	0.646	96.9	34.4	34.4

Based on data from a gage in Northeast Shark Valley Slough, most of Everglades National Park should have seen favorable water depths and recession rates during the early period of the nesting season. From January to March, depths were less than 1.0 ft and recession rates were about 0.1 ft per week. However, like the rest of the study area, NE Shark Slough experienced significant rainfall in March, April and May causing numerous reversals and making this region marginally effective for foraging.

Methods

We performed two kinds of systematic surveys to document wading bird nesting in Water Conservation Areas 2 and 3 (and beginning in 2002, WCA 1) – aerial and ground surveys. These two kinds of surveys are complementary, and in the Everglades, neither does a good job alone (Frederick et al. 1996). The primary objective of both kinds of surveys is to systematically encounter and document nesting colonies. On or about the 15th of each month between January and June, we performed systematic aerial surveys for colonies, with observers on both sides of a Cessna 182, flight altitude at 800 feet AGL, and east-west oriented flight transects spaced 1.6 nautical miles apart. These conditions have been demonstrated to result in overlapping coverage on successive transects under a variety of weather and visibility conditions, and have been used continuously since 1986.

Once colonies were located, we noted position with an aircraft-grade GPS unit, with the airship positioned approximately over the north end of the colony, and estimated numbers of visible nesting birds while circling at a variety of altitudes (500 – 800 feet AGL). At small colony sizes (<100 nests), the proportional error in estimating numbers is generally small. However, as colony size grows beyond that, the bias is generally to underestimate numbers (Erwin 1982, Prater 1979), and controlled experiments with simulated counts have demonstrated both large bias (cf 40%) and large inter-observer differences in bias (Frederick et al. 2003). In addition, the latter study also demonstrated that bias can be greatly reduced (by approximately half) through the use of counts of aerial photographs taken at the time of survey. For this reason, in this study digital photographs of the larger colonies were taken from overhead and multiple angles, and counted later via projection. Due to the extremely large numbers of nests at the Alley North (= Rescue Strand) colony in the recent past (since 1998), we adopted some new techniques for estimating numbers of nests from the air. The majority of birds were nesting underneath the tree canopy, leading to a likely massive undercount using aerial estimation and photographic methods. We therefore counted the numbers of nests on the ground in quadrats of known size, and then compared these counts with aerial estimates of nests in the same area. The quadrats were marked on the ground with white paint on trees at the corners in such a way that they could be seen in photos taken from the air. This comparison allowed us to derive a correction factor to apply to the raw counts from aerial photos, in order to achieve an estimated total number of nests.

Systematic ground surveys of colonies by airboat were done between early April and late May, and were designed to locate and document small colonies or those of dark-colored species that are difficult to detect from aerial surveys. GPS-guided belt transects were generally in north-south orientations, and were also designed to give overlapping coverage. The width of belt transects varied between 0.5 nautical miles apart in WCA 3. Where islands were widely spaced, we could keep mental track of a wider field of view, and so the width of the belt transect would increase in order to maximize efficiency. All tree islands were approached closely enough to flush nesting birds, and nests were either counted directly, or estimated from flushed birds.

In the past, we have performed systematic, 100% coverage ground surveys of colonies by airboat in WCAs 1, 2 and 3 once between early April and late May. In 2005, 100% coverage ground surveys throughout the WCAs were discontinued due to a change in MAP guidelines for monitoring (concentrating instead on measuring size and species composition of large colonies of white-colored waders). However, we did perform some systematic ground surveys in WCA 3 that allow for a direct comparison of densities of colonies in certain areas. This was designed to give an index of abundance for small colonies and dark-colored species in a fashion that might be sustainable.

It should be clear that this flushing technique works only for smaller colonies, since in large colonies the counting is much more difficult, and many of the birds in the interior would not flush.

We conducted ground surveys between 29 March and 2 April 2005. The ground survey belt transects in WCA 3A extended from Tamiami Trail to I-75 (Alligator Alley). East/West boundaries are found in Table 1.7.

Table 1.7. East/West boundaries for Ground Survey transects, WCA 3A.

Transect #	Eastern Boundary	Western Boundary
1	80° 40.300’	80° 40.600’
2	80° 40.900’	80° 41.200’
3	80° 41.500’	80° 41.800’
4	80° 42.100’	80° 42.400’
5	80° 42.700’	80° 43.000’
6	80° 43.300’	80° 43.600’
7	80° 43.900’	80° 44.200’
8	80° 44.500’	80° 44.800’
9	80° 45.100’	80° 45.400’
10	80° 45.700’	80° 46.000’
11	80° 46.300’	80° 46.600’
12	80° 46.900’	80° 47.200’
13	80° 47.500’	80° 47.800’
14	80° 48.100’	80° 48.400’
15	80° 48.700’	80° 49.000’
16	80° 49.300’	80° 49.600’

These large colonies were generally few in number and were counted by a combination of aerial survey estimation and photo-counts for white-colored species (as above), and walk-through counts. An example of how these techniques are combined is shown by the “Hidden” colony (also called in previous years “L-28”, and “40-mile bend”) located in extreme southwestern WCA 3. This colony has substantial numbers of Great Egrets, and large numbers of Snowy Egrets, Tricolored Herons, Anhingas and Little Blue Herons. The colony is largely in dense cypress woods, and visibility from the ground is limited to tens of meters. The Great Egrets and Snowy Egrets are typically counted from aircraft at what was perceived to be their maximum density during incubation periods (February or early March for GREG, late March or April for SNEG). The Tricolored Herons, Anhingas and Little Blue Herons were systematically counted during incubation stage on foot, using 3 – 6 observers walking abreast, spaced 5 – 15 m apart along compass lines. Nests of the three small herons (Snowies, Tricoloreds and Little Blues) are indistinguishable unless chicks are present. Generally, Snowy Egrets nested in groups that were discernable as the birds flushed. Where chicks were not present, we estimated species proportions of nests based on numbers of birds flushed from particular areas.

As part of an effort to measure nest turnover in colonies, we also estimated nest success in several colonies, by repeatedly recording the contents and fates of marked nests. We established belt transects in Alley North, Vacation, Vulture and Cypress City colonies early in the nesting period and marked active nests within a designated distance from the center of the transect. We then returned every 5-7 days to walk transects and check the progress of those nests, count failures and add new nesting attempts to the transect. Nest success was expressed using Mayfield's method for pro-rating survival on a daily basis.

Determining optimal transect widths for systematic colony surveys in mangrove and cypress regions of ENP and BICY.

We began an investigation to determine optimal transect widths for systematic wading bird survey flights conducted in mangrove and cypress environments. The basic method for determining transect spacing is to measure lateral detection distances for naive observers. To do this requires active colonies in natural vegetation. There were no colonies of note in Big Cypress National Preserve at the time of testing, but 3 test flights were conducted between 31 May to 7 June at 8 known mangrove colonies in the western and southwestern regions of ENP. One "informed" and two naive observers flew past colonies at progressively shorter lateral distances to assess detection probabilities. Additional test flights and subsequent analyses are scheduled for the 2006 season.

Results

Nesting Effort

Combining all species at all colonies in LNWR, WCA 2, and WCA 3, we estimated a grand total of 24,248 nests of wading birds (Cattle Egrets, Anhingas and cormorants excluded) were initiated between February and July of 2005 in the WCAs (Table 1.8, see also Appendices 1.3 and 1.4). Note that this figure does not include birds nesting at the Tamiami West and East colonies; although we monitored these colonies, they are technically part of Everglades National Park.

It is also important to realize that this total may not be entirely comparable to previous years, since we did not perform the same level of effort in the ground surveys (eg, complete ground surveys may increase the totals). One way to make the 2005 grand total estimate more comparable to previous years is to consider that on average, ground surveys alone have contributed approximately 30% of the total numbers of nests on average (Frederick et al. 1996). If we take the numbers of nests estimated from aerial surveys in the WCAs during 2005, and add 30% (30,412), this would probably be closer to the estimate if we had completed a comprehensive ground survey. We are planning to refine this estimate in the near future by comparing ground surveys in 2005, transect by transect, with earlier years.

These estimates of nests also do not take into account the bias from aerial survey methods. We estimated this bias by counting four large (cf 2 ha) marked areas both from the ground and the air for Great Egrets (Table 1.9). This species typically has large nests in the tops of trees and is considered relatively easy to quantify from aerial platforms. However, we found that aerial counts from photos underestimated true numbers by 13 – 60%, with a slight overestimate (9%) in only one of the quadrats. There was no obvious relationship between error and degree of vegetative cover, though the sample size is low for this determination. The average error was 28%, with a standard deviation of 38%.

These measurements are suggestive that we are underestimating the true numbers of nests, especially in large well vegetated colonies, by something approaching 28%. Using that figure as a correction, this would put the true numbers of GE nests closer to 4,500 nests. It is unclear at the moment whether similar corrections could be applied to ibises or other species, and it is also unclear whether the same corrections could be applied to large and small colonies alike. In any case, it is clear that past estimates did not include such corrections and were largely derived from aerial estimates. For comparisons with other years, then, we suggest using the raw figures reported in Table 1.8.

Using the lower of the two figures above (grand total of 24,248), the size of the nesting aggregation in 2005 in the WCAs and LNWR combined was slightly under 100% of the average of the past ten years, 61% of the average of the last five years, and about 40% of the recent high of 2002. Numbers of Great Egret nests were 52% the average of the last five years, and 68% of the average of the last ten. In 2004, Wood Stork nests were very much reduced, with only 20 pairs attempting to nest in the WCAs. White Ibis nests were 71% of the average of the last five and 130% the average of the last ten years. Compared with the banner year of 2002, only half the ibis pairs (50.7%) nested in 2005.

The ground surveys that we accomplished totaled approximately half of WCA 3A, and were located in a large area that has in the past had high colony densities. We used this survey as an indicator for change in numbers of species that are poorly quantified by aerial surveys alone (dark-colored species). We have so far compared the numbers from this survey with numbers of nests from the same area of ground surveys in 2004. In 2005, we found 1.2 times the number of Tricolored Herons as in 2004, 1.3 times the Great Blue Herons, 2.4 times the Anhingas, and 0.9 times the Little Blue Herons. If this survey can be taken as an honest indicator of nesting by these species in the larger Everglades, it does not seem as though the dark-colored species that nest in small colonies experienced as much of a decline as the white-colored species nesting in large colonies. This fits with a general pattern of dark-colored species doing well in wet winter-spring breeding seasons, and white colored species doing poorly, that has been seen during the middle 1990's.

In terms of total numbers, the 2005 nesting event in the WCAs can be considered a considerable reduction from the very large and steadily increasing numbers seen in 1999 – 2004. While this numerical reduction seems like a change from the increasing trend of nesting numbers, it should be remembered that the numbers were quite large given the deep and rising water level conditions that prevailed during the most important part of the nesting season.

Nesting Success

In general, nesting success (probability of a nest raising one or more young to fledging age) was very low this year, with nearly all colonies experiencing abandonment of the majority of nests at some point during the season. Wood Storks initiated nesting somewhat late even by the standards of the last 20 years (early to mid-February), and experienced extremely poor nest success. Of 59 nests marked in Tamiami West in March, none survived to produce fledged young, and most abandoned by the egg stage. Most abandonments occurred between 18 March and the first week of April.

We monitored the success of individually identifiable nests at Alley North (Great Egrets, White Ibises, Unidentified Small Herons), Big Melaleuca (GREG), Cypress City (GREG), Vacation Island (GREG) and Vulture Hammock (GREG) in WCA 3, and estimated probabilities of nest success (fledging at least one young) using Mayfield's (1965, 1971) method (Table 1.10). We found uniformly poor nesting success at all the colonies for all species, with fewer than 10% of nests fledging young for any species or colonies, widespread abandonments at most, and low variance in estimates of nest success.

Great Egrets were nesting in large numbers by late February, which suggests a relatively normal initiation schedule. We found evidence of complete or large scale abandonments by Great Egrets at most of the colonies that we surveyed from the air, and all of those at which nesting success was tracked through marked nests (Alley North, Cypress City, Vulture, Vacation). Great Egrets have in the past been the least likely species to abandon nesting in the Everglades, suggesting that the spring of 2005 was particularly unfavorable for nesting. Mayfield estimates of nest success for Great Egrets ranged from 0 – 10% depending on colony.

White Ibises began nesting at Alley North, and Tamiami West in early March. We estimated through aerial photographs and the use of ground counts that there were at least 12,750 nests in the Alley North colony by mid March, many of them nesting in cattails along the southwest perimeter of the colony. However, these counts are almost certainly considerable underestimates of the true numbers, since we were aware that several thousand ibises must have been nesting in the willows, but we were unable to count them completely because many were underneath the canopy. In addition, there were many nests still in courtship stage at the time of the March survey, which were not included in the total since they had not laid eggs, and had abandoned by the time of the April survey.

Most of the ibis nests in the cattails were abandoned in late March, following a series of rainfall events and rising water alluded to in the summary of this report. Just north of the Alley North colony (Gauge 3A-NE), water levels in March rose by a total of 30 cm, resulting in deeply flooded foraging areas and in some cases inundated nests. These nests were in early chick or late incubation stages at the time of abandonment. By early April, nearly all of the ibises had abandoned in this area, and the colony was frequented by large numbers of vultures.

Table 1.8. Numbers of nests of aquatic birds found in Loxahatchee National Wildlife Refuge (WCA 1) and WCAs 2, 3, during systematic surveys, January through July of 2005. Individual colonies reported here are those with more than 50 pairs (all species not including Cattle Egrets, Anhingas or cormorants).

Latitude	Longitude	WCA	Name	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLIB	CAEG	Colony Total*
N26 31.834	W80 15.977	1	Lox 111		2,458												2,458
N26 26.396	W80 23.473	1	Lox 99	935	536						134						1,605
N26 27.609	W80 14.442	1		226							104						330
N26 33.580	W80 15.060	1	Canal North									264					264
N26 33.081	W80 26.568	1										261					261
N26 28.093	W80 22.362	1		105													105
N26 22.076	W80 15.481	1		53													53
N26 12.130	W80 31.750	3A	Alley North	850	12,750		150	25	300	150	2,250	200	10		75		16,610
N25 48.080	W80 29.400	3B	3B Mud E	480		20	30		10								510
N26 11.763	W80 49.493	3A										233					233
N26 06.136	W80 27.435	3A		59	93												152
N26 01.331	W80 32.213	3A	Vulture	121			25	5									126
N26 07.468	W80	3A	Cypress	107			30	6									113

	30.163		City														
N25 52.142	W80 48.357	3A							55			65					120
N25 46.360	W80 50.240	3A	Hidden	38	63		10										101
N25 54.939	W80 37.813	3A	Vacation	79			20	6									85
N25 57.880	W80 34.480	3A	L-67	104													104
N26 18.715	W80 20.709	2A		37								56					93
N26 07.550	W80 32.500	3A	6th Bridge	75													75
Totals from colonies > 50				3,269	15,900	20	265	42	365	150	2,488	1,079	10	0	75	0	23398*
Totals from colonies < 50				302	100	0	507	155	23	70	3	154	0	1	43	0	851*
	GRAND TOTALS**			3,571	16,000	20	772	197	388	220	2,491	1,233	10	1	118	0	24249*

Latitude and longitude in degrees, decimal minutes. *Totals do not include Cattle Egrets or Anhingas.

Table 1.10. Reproductive statistics for calculation of nest success (P) and success during incubation and nestling periods (Pj) for all nests monitored in 2005. See definitions for nest parameters below.

Colony	Species	Period	K	ΣY	ΣT	p	v	j	Pj	Vj	P	V
ALLEY N	GE	incubation	23	6	169.5	0.900	0.0005	28	0.052	0.0014		
ALLEY N	GE	Nestling	9	1	82.5	0.903	-0.0011	21	0.117	-0.0079	0.006	0.0000
ALLEY N	SH	incubation	21	1	198.5	0.899	0.0005	22	0.097	0.0026		
ALLEY N	SH	Nestling	7	4	29	0.897	-0.0032	14	0.217	-0.0367	0.021	-0.0003
ALLEY N	WI	incubation	440	121	4323	0.926	0.0000	21	0.200	0.0003		
ALLEY N	WI	Nestling	108	61	907.5	0.948	-0.0001	14	0.475	-0.0027	0.095	0.0000
BIGMEL	GE	incubation	14	2	45	0.733	0.0043	28	0.000	0.0000		
BIGMEL	GE	Nestling	0	0	0			21			0.000	0.0000
CYPCITY	GE	incubation	13	0	39.5	0.671	0.0056	28	0.000	0.0000		
CYPCITY	GE	Nestling	24	3	290	0.928	-0.0002	21	0.206	-0.0051	0.000	0.0000
VACISL	GE	incubation	30	13	255.5	0.933	0.0002	28	0.145	0.0046		
VACISL	GE	Nestling	21	11	294.5	0.966	-0.0001	21	0.484	-0.0123	0.070	0.0008
VULTURE	GE	incubation	96	23	519.5	0.859	0.0002	28	0.014	0.0001		
VULTURE	GE	Nestling	22	17	306.5	0.984	-0.0001	21	0.708	-0.0120	0.010	-9.3755

Definitions: K= Number of nests observed, Y = # nests surviving observation period, T = number of nest-days observed during period, p = daily survival rate, v = variance in daily survival rate, j = #days in period, pj = survival rate of nests for the period, vj = variance in period nest success, P = proportion of nests estimated to have survived the entire nesting cycle, V = variance of P.

Several thousand young were found in the cattails at this time, but given their weakness and poor nutritional condition it seems unlikely that many survived. In all, we followed the fates of 478 nests in Alley North, and found 19% of them fledged young (traditional nest success measure). Mayfield nest success estimates were less than 10%, with very low variance of this estimate. We did not follow the fate of the ibises at Tamiami West closely, since we were attempting to stay out of the colony to give endangered Wood Storks every chance to nest. Very few ibises were found in the Loxhatchee colonies (99 and 111) during the March surveys, suggesting that the large numbers found in April had not initiated by late March and so may not have endured the high water conditions at that time. There is also the strong possibility that the Loxahatchee birds found in April may have come from the abandoned Alley North colony in WCA 3A N. Combining the numbers of nests from Alley North and the Lox colonies may therefore be a gross exaggeration of the total numbers of nesting pairs of ibises in 2005, since many of those in Loxahatchee and Alley North could have been the same individuals.

Table1.9. Comparison of ground and aerial counts of Great Egret nests in marked quadrats in Alley North colony during 2005.

Quadrat #	Date	Species	Ground Count	Aerial count	% Error	Cover
2005-1	3/20/05	GE	23	20	-13	low
2005-2	3/20/05	GE	54	21	-61	medium
2005-3	3/20/05	GE	10	11	9	high
2005-4	3/26/05	GE	8	4	-50	low
total			95	56	-41	
Mean error					-28.8	
Standard. Deviation of mean					32.5	

Optimal width of survey transects in mangrove habitat

Our preliminary tests reveal substantial variation in the ability of both naïve and informed observers to detect wading bird colonies in mangroves (Table 1.11). Some of the smaller wading bird colonies were never detected by naïve observers, even the were flown almost directly over them. When detected, detection distances appeared to be as low as 0.4 nautical miles. Colony size, species composition, cloud cover, and direction all appear to play a role, though our sample size is not large enough to detect statistically significant effects of these factors. In addition, it should be noted that these preliminary detection distances are for white colored species only. Additional tests will be needed in the 2006-07 breeding seasons in order to confidently determine the optimal aerial survey transect width.

Table 1.11. Preliminary results for colony detection of white plumaged wading birds during aerial surveys in mangrove habitat. All detection distances are in nautical miles (nm).

	Colony Size	Dominant Species	Distance of first detection by	Distance of first detection by naive

		informed obs. (nm)	observers (nm)
450	SNEG	0.6	0.6
105	WHIB	1.0	1.0
100	GREG	1.2	1.0
90	GREG	0.6	0.2
75	WHIB	0.4	not
75	WHIB	0.8	not
35	SML WH	0.8	0.8
5	WOST	0.6	not

Discussion

In general, the weather, hydrology, and nesting responses of wading birds were relatively uniform across the study area in 2005. In all areas, drying trends were initially favorable for nesting through early February, and reasonably large numbers of wading birds were attracted to the area – in fact, Systematic Reconnaissance Flight surveys showed 288% more birds in the system in February 2005 than in February 2004, and 20% more than in the banner nesting year of 2002. So the conditions were apparently initially attractive to wading birds although many of these may have been migratory animals. In addition, for spoonbills that nested early in Florida Bay, nesting success was quite high (100% in one case, see South Florida Wading Bird Report). However, heavy rainfall and significant increases in water levels were felt throughout the south Florida ecosystem in late February and most of March, leading to poor feeding opportunities and widespread abandonment of nests of virtually all species monitored closely. With the possible exception of Lake Okeechobee (only one survey performed), all other areas (Florida Bay, mainland ENP) reported widespread abandonment and very poor nesting success, however. The fact that Great Egrets did very poorly may also be significant – they have in the past been the most robust to deep water and increasing water levels during the nesting season.

The numbers of nesting wading birds met the criteria for restoration only for Great Egrets and White Ibises – all others fell below or well below the targeted 5-year running average goals. In addition, there was no indication that storks were moving into the coastal region of Everglades National Park, nor that they had any inclination to nest earlier in the year. This is somewhat surprising, since the early drying trends were quite favorable in most parts of the system, and extremely favorable in some (90th percentile in some of the WCAs). As above, large numbers of birds were attracted to the south Florida ecosystem, so the numbers of potential nesters did not seem to be the issue. So there appeared to be something missing from the suite of conditions necessary to cue early nesting. It may be significant however, that several of the historical colonies or historical regions of colonies in coastal ENP were occupied by small numbers of birds both this year and last – this trend may be indicative of building use of the area, which is one of the criteria in the CERP for healthy wading bird nesting.

Summary of nesting in 2005.

The poor nest success and abandonment throughout the region seemed rather clearly to be related to unseasonable weather rather than any particular management pattern, especially since the effects were uniform throughout the region. In the context of the longer term history of nesting, however, the numbers of initiations in this year of poor conditions may be seen as remaining well above the average of the past 20 years (see summary in Table 1.12, and historical comparison in Figure 1.17). A large increase in total nesting numbers occurred in about 1999, and appears to be persistent, even in the face of poor nesting conditions like 2005. This suggests that something relatively permanent has occurred to boost the baseline level of nesting.

Table 1.12. Total numbers of wading bird nests initiated in 2005 in the South Florida Ecosystem.

Area	WOST	WHIB	GREG	SNEG	TCHE	LBHE	ROSP	Other	TOTAL
Lake Okeechobee	0	0	1,590	0	28	9	0	0	1,627
WCAs 1, 2, and 3	20	16,000	3,571	2,491	388	1,233	10	536	24,249
BICY	0	0	285	0	0	0	0	0	285
ENP mainland	253	945	626	150	14	0	2	0	1,990
Florida Bay	0	200	60	0	0	0	517	0	777
Ecosystem total	273	17,145	6,132	2,641	430	1,242	529	536	28,928

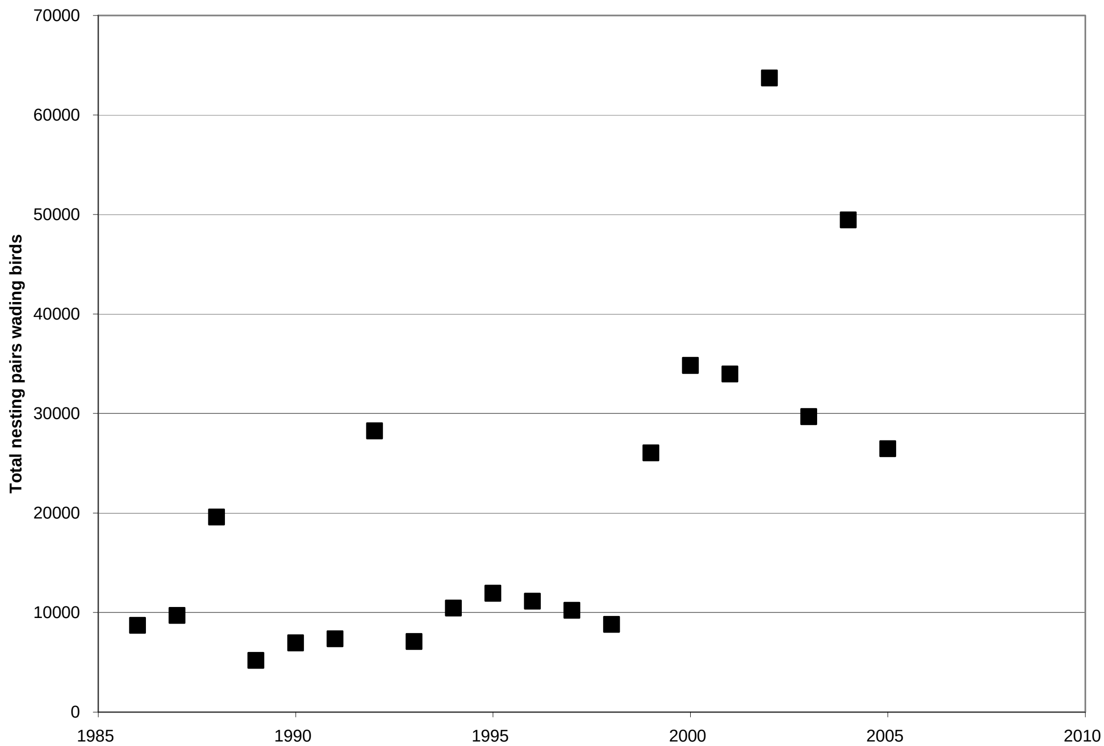

Figure 1.17. Total numbers of all long-legged wading birds nesting in the WCAs, ENP, BICY and Florida Bay, 1986 – 2005. Note that Lake Okeechobee totals have been left out of this comparison since there are few earlier comparison figures.

Nesting in the previous several seasons in the central Everglades has been unusually large and successful for most species, and it is possible that the large numbers that nested in 2005 despite poor conditions were a result of short-term philopatry (tendency to return to previous nesting, in this case possibly because of prior nesting success). It seems numerically impossible for the large numbers of birds in 2005 to have been the result of local recruitment from previous years, and instead it seems more likely they were adult birds returning to nest. During late 2002, the drought in the southeastern U.S. had broken, and wetlands in most southeastern states became rehydrated, opening up opportunities for nesting waders that had not existed during the drought years of 2000 – 2002. The large and persistent nesting aggregations in the Everglades 1999 – 2005, despite the early season weather and the existence of these other places for nesting, seems to emphasize a certain degree of philopatry as an explanation for the 2005 event. Although varying degrees of philopatry have certainly been noted before for herons and storks (Frederick 2001), there has been almost no evidence of philopatry noted before for ibises (Kushlan and Bildstein 1992, Frederick and Ogden 1998). However, this may be because ibises are usually compared as a species with other species that are generally more philopatric.

The magnitude of possible undercount, especially for ibises, is of interest to managers and scientists alike. On the one hand, this seems to present little real difficulty in comparisons with past years and surveys, simply because those past years must have been susceptible to the same potential for bias and undercount. On the other hand, the bias stems from ibises nesting underneath the canopy, which seemed to be exaggerated by comparison with the past ten years at one of the major colonies (Alley North). Of course, its unknown whether the degree of nesting under the canopy (with resulting underestimation) has been as much or more of a problem in counts prior to the 1990's; considering the range of colony vegetation types, it probably has been at some time. So it is clear that the 2005 count of ibises is an undercount of some large magnitude, but whether this matters or not in the larger picture of nesting during the past century is unknown. The lesson from this frustration is that we should continue to estimate the bias in our counts, and do so consistently in the future. As long as the raw estimates are also preserved, there is no tradeoff with being able to compare directly with past counts.

Analysis of nesting effort and success during 1999 - 2005

The dramatic changes in nesting effort during the period 1999 – 2005 were large enough and sufficiently unprecedented to demand explanation, even if the explanations are partly speculative. The period of 1994 – 1997 was one of generally high water conditions, during which very few storks, ibises, or Snowy Egrets nested, and both numbers and nesting success of Great Egrets and Great Blue Herons increased. During this time, there were no years in which large portions of the marsh surface dried, at least within WCAs 3, 2, and the southern half of WCA 1. In contrast, the marsh surface was considerably drier during the period 1999 – 2001, with only about half the WCAs being wet by May of 2000 and 2001, and slightly more during 1999. Nonetheless, this idea of drier conditions is only by comparison with the very wet conditions of the mid-1990's. Neither stage nor rainfall during 2000 and 2001 could be considered low by comparison with long-term records, and in most water management units, stages were high to normal.

Nesting effort of storks (Kushlan et al. 1975) and ibises (Frederick and Collopy 1989) has been linked in a statistical way with the rapidity of drying of the marsh surface. This correlation between nesting effort and drying rate certainly held true for the period of 1998 – 2001. In 1998, water levels were high and drying rates low, and nesting effort was the lowest of the four years. Drying rates were substantially higher in 1999, 2000 and 2001, with nesting increasing almost in direct proportion to the drying rate. Although drying rate is therefore correlated with nesting effort during the study period, there may be other important factors that led to the high nesting effort in 1999 – 2005.

First, there is evidence that drying rate alone is a poor explanation for nesting effort in many other years in the record. During 1995, for example, drying rate was virtually the highest on record in many WCAs, yet a very poor nesting year ensued; this was a very high water year, however, and despite the rapid drying, surface water was still quite deep by the middle of the nesting season. Similarly, during 1988, 1989 and 1990, drying rates were extremely rapid, yet little or no nesting occurred in these years. These were years in which most or all of the marsh surface dried during the spring and early summer, and although drying was fast, there was apparently too little water to support foraging for very long in most areas. Thus rapid drying apparently must be accompanied by water levels that are neither extremely deep, nor extremely shallow over much of the marsh. It is possible that the rapid drying of the 2000 and 2001 seasons was accompanied by water levels at or close to some optimum in this regard. In any event, drying rates by themselves can only explain a small proportion of variation in annual numbers of nests (cf 20%).

The effect of antecedent drought conditions on fish community dynamics and fish abundance is another possible explanation for the nesting pattern observed. This theory suggests that some aspect of drought conditions causes a flush of exceptionally high densities of small "forage" fishes. Although the mechanism is unclear, the predicted pattern of exceptionally large nestings immediately following the cessation of droughts has been well supported by the historical nesting record (Frederick and Ogden 2003). However, the 2000 - 2005 nesting seasons did not conform to the predictions of this hypothesis. The nesting events in 2000, 2001 and 2002 qualified as exceptionally large nestings in the context of recent history, yet none was preceded by any exceptionally strong drying event. Instead, these years were preceded by an exceptional period of high water (1994 – 1997), with less exceptional, but higher than normal stages through 1999. It therefore seems unlikely that the antecedent drought hypothesis offers much explanation for why 2000 – 2002 had such high nesting effort. So these nesting seasons offer an important perspective on the antecedent drought hypothesis – although antecedent periods of drought are apparently sufficient to produce extremely large nesting events in the Everglades, they are not the only conditions that will necessarily produce big nesting events.

During 2000 and to a lesser extent 2001, drought conditions prevailed throughout much of the southeastern U.S. This drought resulted in the drying of many marshes, streams and even lakes, leaving much of the habitat typically available to wading birds with little or no surface water. In most cases, wading bird colonies were not even initiated in these dry or drying areas. For example, by late March 2000 only one of the 11 known Wood stork colonies in Georgia had initiated nesting. In north Florida, most wading bird colonies did not initiate, and those that did were not successful. The drought in 2000 was severe enough to affect large areas of freshwater wetlands in Georgia, parts of South Carolina, north Florida and Alabama. South Florida was therefore one of the only places in the region that held water during the drought. Thus most of the wading birds in the southeastern U.S. were left with little habitat during spring 2000, and it is quite likely that the large numbers of birds in south Florida included many birds that typically nest in other states. In support of this hypothesis, Corkscrew Swamp Sanctuary also had many more storks attempt to nest than usual during 1999 and 2000; this area was also wet, but has obviously not had the same water management history as the Everglades. Although the drought conditions in 2001 were not as extensive throughout the southeast as in 2000, much of peninsular Florida remained too dry for nesting. It is also possible that there was an effect of prior experience that resulted in many birds returning to nest in the Everglades in 2001, as a result of having had excellent nesting success there in 2000. The influence of prior experience on choice of nesting location is poorly documented for wading birds.

Finally, there is the possibility that the large nesting events of 2000, 2001, and 2002, and the somewhat smaller event of 1999 were related to the decrease in mercury contamination recorded over the period 1994 – 2005 (cf 90% reduction). Over this period, a standardized measure of mercury contamination in Great Egret nestling feathers decreased by over 85%, possibly as a result of reduced atmospheric inputs of mercury from local waste-burning facilities (Frederick et al. 2001). This reduction in contamination has been quite significant in predatory fish as well, suggesting that the entire food chain has become considerably less contaminated.

Mercury has many potential sublethal effects on wading birds, including lethargy, altered immunology and blood chemistry, lower fledging weights, altered adult reproductive and parental behavior, altered chick behavior, reduced survival, and effects on hormone levels. Feather mercury levels in adult ibises are associated with elevated testosterone and depressed estrogen levels at particular stages of reproduction (Heath 2003). Although this evidence is suggestive of a causal relationship between mercury and endocrinology, this does not constitute hard evidence of mercury-related effects on reproduction. Nonetheless, experimental work with other species has indicated a causal relationship between mercury and hormone production, and it therefore seems likely that the correlative evidence we have presented is indicative of a causal relationship – high mercury contamination causes reductions in breeding or breeding success.

Although stage-specific effects have yet to be measured, it is not implausible that mercury contamination could have an effect on the ability of birds to come into reproductive condition. The interplay between day-length, body condition, and endocrinology as causative agents in the initiation of breeding is not very well worked out in many birds. However, if mercury is likely to disrupt the production or reception of hormones, and is likely to alter appetite, health and body condition, it seems quite possible that at some concentration, mercury could alter the thresholds of physiological and ecological cues used by birds to breed. Although the available evidence from the Everglades does not allow us to conclude that reductions in mercury were a contributing factor to the large nestings of the last several years, we are certainly unable to reject this hypothesis, and believe it should be retained as one of a suite of potential explanatory variables.

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Appendix 1.3. Locations and species composition of all colonies of wading birds found in WCAs 2 and 3 of the Everglades during Janaury through June of 2005.

WCA	Latitude			Longitude			Colony Name	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YC
3B	N	25	48.080	W	80	29.400	3B Mud E	480		20	30		10					
3B	N	25	55.401	W	80	30.993		17										
3B	N	25	48.869	W	80	36.079		14										
3B	N	25	50.454	W	80	31.682		6										
3B	N	25	50.404	W	80	31.821		6										
3B	N	25	50.907	W	80	31.930		5										
3A	N	26	12.130	W	80	31.750	Alley North	850	12,750		150	25	300	150	2,250	200	10	
3A	N	26	11.763	W	80	49.493										233		
3A	N	26	06.136	W	80	27.435		59	93									
3A	N	26	01.331	W	80	32.213	Vulture	121			25	5						
3A	N	25	52.142	W	80	48.357							55			65		
3A	N	26	07.468	W	80	30.163	Cypress City	107			30	6						
3A	N	25	57.880	W	80	34.480	L-67	104										
3A	N	25	46.360	W	80	50.240	Hidden	38	63		10							
3A	N	25	54.939	W	80	37.813	Vacation	79			20	6						
3A	N	26	07.550	W	80	32.500	6th Bridge	75										
3A	N	26	06.342	W	80	42.061			1				2			36		
3A	N	26	00.660	W	80	46.417		5	25									
3A	N	25	46.293	W	80	41.632		24			36	1	1					
3A	N	25	57.678	W	80	48.381			25									
3A	N	25	49.239	W	80	40.616	Yonteau	24			10							
3A	N	26	13.618	W	80	48.223										24		
3A	N	26	07.651	W	80	43.437							3	1		19		

3A	N	26	00.609	W	80	45.825		23						
3A	N	25	46.658	W	80	41.645	17			1				
3A	N	26	00.055	W	80	48.043						14		
3A	N	26	02.288	W	80	44.137		9					1	
3A	N	25	59.126	W	80	48.921					1	8		1
3A	N	25	58.892	W	80	48.970					3	6		
3A	N	25	49.405	W	80	40.319			9	8				
3A	N	25	49.694	W	80	40.545			9	8				
3A	N	25	54.081	W	80	44.331	1		13	7				
3A	N	25	53.223	W	80	42.105	3		16	4				
3A	N	26	01.369	W	80	44.057						7		
3A	N	25	55.262	W	80	43.397			8	6				
3A	N	25	55.997	W	80	42.850	3		6	2				
3A	N	25	56.229	W	80	44.130	1	3		1				
3A	N	25	58.508	W	80	46.473	5							
3A	N	25	59.145	W	80	48.797				1		4		
3A	N	25	50.134	W	80	41.119			14	4				
3A	N	26	01.524	W	80	41.576	1					3		
3A	N	25	54.485	W	80	41.577	1			1		2		
3A	N	25	51.063	W	80	41.592			7	4				
3A	N	25	50.790	W	80	42.200			16	4				
3A	N	25	53.822	W	80	42.284				4				
3A	N	25	47.874	W	80	42.844	4							
3A	N	25	48.602	W	80	43.845	1		4	3				
3A	N	26	01.699	W	80	45.362				1		3		
3A	N	25	51.196	W	80	45.436	3		4	1				
3A	N	25	48.355	W	80	45.769			1	4				
3A	N	25	59.466	W	80	46.479	1	3						
3A	N	25	51.436	W	80	47.601			2	4				
3A	N	26	00.823	W	80	48.807						4		
3A	N	25	55.797	W	80	41.618	2		1	1				
3A	N	25	49.414	W	80	42.808			1	3				
3A	N	25	52.489	W	80	44.126				3				

3A	N	25	54.601	W	80	44.805	2					1		
3A	N	25	58.236	W	80	45.752	2				1			
3A	N	26	04.626	W	80	45.807						3		
3A	N	26	00.019	W	80	45.828							1	2
3A	N	25	53.075	W	80	45.989	3			1				
3A	N	26	04.213	W	80	46.333							3	
3A	N	25	58.738	W	80	47.633						3		
3A	N	25	52.917	W	80	48.246						3		
3A	N	25	53.246	W	80	48.263		2			1			
3A	N	25	52.921	W	80	48.705		2						1
3A	N	25	49.657	W	80	40.277				4	2			
3A	N	25	56.976	W	80	41.615	2							
3A	N	25	58.780	W	80	41.735	2			8				
3A	N	26	05.622	W	80	41.765		2						
3A	N	25	50.729	W	80	43.292	1			1	1			
3A	N	25	54.703	W	80	43.770	1			1	1			
3A	N	25	47.036	W	80	43.920	1			20	1			
3A	N	25	57.845	W	80	43.997				1	2			
3A	N	25	57.939	W	80	44.257	1						1	
3A	N	25	51.518	W	80	44.675	2			2				
3A	N	25	54.895	W	80	44.802					2			
3A	N	25	57.364	W	80	45.152				2	2			
3A	N	25	48.109	W	80	45.153					2			
3A	N	25	55.789	W	80	45.331	2							
3A	N	25	52.709	W	80	45.446	1				1			
3A	N	25	46.700	W	80	45.771				1	2			
3A	N	26	01.832	W	80	45.779							2	
3A	N	26	02.887	W	80	45.809						1	1	
3A	N	25	49.654	W	80	45.870	2							
3A	N	25	57.505	W	80	46.345	1				1			
3A	N	25	47.543	W	80	46.389					2			
3A	N	25	47.487	W	80	46.571					2			
3A	N	25	48.300	W	80	46.931					2			

3A	N	25	47.901	W	80	46.959			5	2	
3A	N	25	46.264	W	80	47.126				2	
3A	N	25	46.496	W	80	47.144				2	
3A	N	25	46.451	W	80	47.661				2	
3A	N	25	54.482	W	80	48.126	2				
3A	N	25	59.015	W	80	48.128					2
3A	N	25	59.150	W	80	48.179					2
3A	N	25	56.209	W	80	48.190	2				
3A	N	25	59.248	W	80	48.242					2
3A	N	25	57.449	W	80	48.288	2				
3A	N	25	57.499	W	80	48.698		1		1	
3A	N	25	49.978	W	80	49.345				2	
3A	N	25	57.891	W	80	49.467	2				
3A	N	25	49.735	W	80	49.525	1			1	
3A	N	25	53.603	W	80	40.579			2	1	
3A	N	25	56.414	W	80	40.861			2	1	
3A	N	25	51.301	W	80	40.880				1	
3A	N	25	50.057	W	80	41.206			4	1	
3A	N	25	49.894	W	80	41.576	1				
3A	N	25	45.850	W	80	41.709			1	1	
3A	N	25	53.753	W	80	41.710		1			
3A	N	26	04.287	W	80	41.765	1				
3A	N	25	51.577	W	80	41.814			1	1	
3A	N	26	00.359	W	80	41.841	1				
3A	N	26	07.713	W	80	42.130		1			
3A	N	25	48.529	W	80	42.171					1
3A	N	25	51.246	W	80	42.181	1				
3A	N	26	06.669	W	80	42.249					1
3A	N	25	49.922	W	80	42.264	1				
3A	N	25	46.625	W	80	42.700				1	
3A	N	25	48.908	W	80	42.782			4	1	
3A	N	25	48.923	W	80	42.867			2	1	
3A	N	25	46.766	W	80	42.891			9	1	

3A	N	25	54.880	W	80	43.368			1		
3A	N	25	54.634	W	80	43.369		2	1		
3A	N	25	57.450	W	80	43.405			1		
3A	N	25	50.618	W	80	43.477			1		
3A	N	25	46.376	W	80	43.879		2	1		
3A	N	25	47.791	W	80	43.900		24	1		
3A	N	25	46.662	W	80	43.964		1	1		
3A	N	25	46.463	W	80	44.009		2	1		
3A	N	25	47.395	W	80	44.237					1
3A	N	25	54.850	W	80	44.350		23	1		
3A	N	25	53.633	W	80	44.640		2	1		
3A	N	25	54.377	W	80	44.692			1		
3A	N	25	48.126	W	80	44.789		1	1		
3A	N	25	56.564	W	80	44.799			1		
3A	N	25	52.037	W	80	44.837		1	1		
3A	N	25	55.116	W	80	44.855		1	1		
3A	N	26	02.825	W	80	45.243			1		
3A	N	26	02.238	W	80	45.290	1				
3A	N	25	46.895	W	80	45.336		1	1		
3A	N	25	46.674	W	80	45.805		1	1		
3A	N	25	46.819	W	80	45.825			1		
3A	N	25	46.779	W	80	45.850			1		
3A	N	25	51.974	W	80	45.856	1				
3A	N	25	50.011	W	80	45.927			1		
3A	N	25	46.477	W	80	45.960	1				
3A	N	25	47.288	W	80	46.328			1		
3A	N	25	57.326	W	80	46.360				1	
3A	N	25	58.614	W	80	46.369	1				
3A	N	25	55.112	W	80	46.399	1	10			
3A	N	25	46.411	W	80	46.403			1		
3A	N	25	48.870	W	80	46.540		6	1		
3A	N	25	48.622	W	80	46.865			1		
3A	N	25	48.040	W	80	47.010		1	1		

3A	N	25	46.112	W	80	47.093	1				
3A	N	25	48.384	W	80	47.171		2	1		
3A	N	25	54.984	W	80	47.181			1		
3A	N	25	54.898	W	80	47.619	1				
3A	N	25	53.536	W	80	47.633		2	1		
3A	N	25	50.608	W	80	47.697		6	1		
3A	N	25	56.422	W	80	48.114	1				
3A	N	25	48.056	W	80	48.215		25		1	
3A	N	25	53.341	W	80	48.265		3		1	
3A	N	25	47.185	W	80	48.335		3	1		
3A	N	25	51.141	W	80	48.375		2	1		
3A	N	25	48.299	W	80	48.413	1				
3A	N	25	48.731	W	80	48.590		1	1		
3A	N	25	49.915	W	80	48.681	1				
3A	N	25	46.656	W	80	48.764			1		
3A	N	25	47.443	W	80	48.840			1		
3A	N	25	59.642	W	80	48.880					1
3A	N	25	47.432	W	80	48.925			1		
3A	N	25	49.161	W	80	40.300		6			
3A	N	25	57.351	W	80	40.436		2			
3A	N	25	49.908	W	80	40.441		5			
3A	N	25	49.242	W	80	40.606		23			
3A	N	25	53.319	W	80	40.752		14			
3A	N	25	50.256	W	80	41.130		1			
3A	N	25	46.748	W	80	42.133		12			
3A	N	25	48.289	W	80	42.214		3			
3A	N	25	51.778	W	80	42.235		8			
3A	N	25	51.808	W	80	42.318		6			
3A	N	25	52.724	W	80	42.373		2			
3A	N	25	48.624	W	80	43.025		1			
3A	N	25	49.422	W	80	43.309		1			
3A	N	25	52.882	W	80	43.466		1			
3A	N	25	47.948	W	80	44.096		4			

3A	N	25	46.629	W	80	44.552				1							
3A	N	25	47.110	W	80	44.579				1							
3A	N	25	46.921	W	80	44.731				2							
3A	N	25	46.314	W	80	44.751				2							
3A	N	25	56.380	W	80	44.754				6							
3A	N	25	47.918	W	80	45.168				1							
3A	N	25	48.180	W	80	45.184				5							
3A	N	25	51.732	W	80	45.230				1							
3A	N	25	47.396	W	80	45.303				1							
3A	N	25	53.775	W	80	45.312				1							
3A	N	25	49.228	W	80	45.333				2							
3A	N	25	49.850	W	80	45.369				2							
3A	N	25	46.597	W	80	45.426				1							
3A	N	25	47.371	W	80	45.718				6							
3A	N	25	48.999	W	80	45.845				1							
3A	N	25	49.006	W	80	46.354				1							
3A	N	25	57.691	W	80	46.408				1							
3A	N	25	50.220	W	80	46.607				2							
3A	N	25	48.865	W	80	46.849				3							
3A	N	25	46.669	W	80	46.983				1							
3A	N	25	51.982	W	80	47.008				1							
3A	N	25	46.313	W	80	47.137				1							
3A	N	25	46.215	W	80	47.532				1							
3A	N	25	55.587	W	80	47.582				2							
3A	N	25	53.567	W	80	47.682				1							
3A	N	25	46.588	W	80	47.773				12							
3A	N	25	48.371	W	80	47.791				6							
3A	N	25	49.076	W	80	48.167				1							
3A	N	25	40.390	W	80	49.015				6							
2A	N	26	18.715	W	80	20.709	37								56		
2A	N	26	14.652	W	80	21.128	37										
2A	N	26	14.376	W	80	18.686	31										
Total, all colonies							2,209	13,004	20	776	201	388	220	2,253	634	11	1

Appendix 1.4. Locations and species composition of all colonies of wading birds found in WCAs 2 and 3 of the Everglades during Janaury through June of 2005.

WCA	Latitude	Longitude	Colony Name	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YC
1	N 26 31.834	W 80 15.977	Lox 111		2,458									
1	N 26 26.396	W 80 23.473	Lox 99	935	536						134			
1	N 26 27.609	W 80 14.442		226							104			
1	N 26 33.580	W 80 15.060	Canal North									264		
1	N 26 33.081	W 80 26.568										261		
1	N 26 28.093	W 80 22.362		105										
1	N 26 22.076	W 80 15.481		53										
1	N 26 31.984	W 80 17.765										44		
1	N 26 23.999	W 80 15.042		27										
1	N 26 35.961	W 80 17.435										19		
1	N 26 31.554	W 80 26.224		11								8		
1	N 26 22.790	W 80 15.700		4										
1	N 26 33.008	W 80 15.000										3		
Totals				1,361	2,994	0	0	0	0	0	238	599	0	0

WADING BIRD NESTING AND WOOD STORK REPRODUCTIVE SUCCESS IN THE CENTRAL EVERGLADES, 2006.

Executive summary

Wading bird nesting responses (timing, location, numbers of nests) are an important variable in evaluating the success of the Comprehensive Everglades Restoration Plan (CERP). This study reports on nesting in the Water Conservation Areas (WCAs) of the Everglades during 2006. Not all species of wading birds are considered of equal importance in monitoring the success of CERP, and the focus is now on large white species, especially Wood Storks, White Ibises, Snowy Egrets, and Roseate Spoonbills.

As a result of late summer rainfall, the WCAs began the dry season (November) with high or very high stages than is typical for the season. This was followed by rapid drying throughout the season, with the exception of two rainfall events in February 2006, which caused temporary reversals in stage. Unlike in 2005, however, there were no major rainfall events in March or April, and the drying trend was essentially uninterrupted between late February and mid-May. Given the abundance of water, and the rapid drying, conditions were essentially perfect for high prey availability during much of the nesting season.

Combining all species at all colonies in LNWR, WCA 2, and WCA 3, we estimated a grand total of 39,677 wading birds (Cattle Egrets, Anhingas and cormorants excluded) were initiated between February and July of 2006 in the WCAs. Note that this figure does not include birds nesting at the Tamiami West and East colonies; although we monitored these colonies, they are technically part of Everglades National Park. The 39,677 figure for 2006 represents a substantial 63% increase over the 2005 total of 24,248 obtained using the same methods. This is a conservative estimate, especially considering that a sizeable upsurge in nesting took place at the Hidden colony where a large portion of birds were obscured by cypress cover. Numbers of ibis nests in '06 were quite similar to the average of the previous five years (within 5%), and 45% greater than the average of the previous ten years. Great Egrets were also similar to the average of the previous five years, and considerably larger than the average of the last ten. Snowy Egrets were the real surprise, with 76% more nests than the average of the last five years, and nearly three times that of the last ten. This continues a trend of rapid increases in nesting numbers for Snowy Egrets in recent years, dominated Alley North and Hidden colonies.

Ground surveys (which largely ignore exclude larger, white-wader colonies visible from the air) yielded a total of 691 wading bird nests (169 locations averaging 4.1 nests per location) in the area surveyed (part of central WCA 3). When Anhingas are included in the totals, we found 1121 nests (190 locations, 5.9 nests per location). By comparison with other years in which surveys for dark-colored species have been carried out within the same transects in WCA 3 (1996 – 2005), we found 40% more Anhingas, 200% the Great Blue Herons, 75% more Tricolored Herons, three times the Black-crowned Night Herons, and 35% fewer Little Blue Herons in 2006. In 2005, we found 40% more Anhingas than on average, 19% more Great Blue Herons, 80% fewer Tricolored Herons, three times the Black-crowned Night Herons, and 85% fewer Little Blue Herons.

Nesting success was markedly higher for all species in 2006 than in 2005. We marked and followed the fates of 233 Great Egret nests, and estimated the mean probability of a nest start resulting in large young in 2006 was 75% compared to 17.6% in 2005 (Mayfield success) with an average number of young fledged per nest slightly over 2.5. Small heron nests (Snowy Egrets, Tricolored Herons, Little

Blue Herons), were similarly successful, with an interspecific average probability of success of 80% (21% in 2005) and an average of 3.2 chicks fledged per nest. Note that Tricolored Herons and Snowy Egrets, where measured in the Alley North colony, showed 100% nest success. We marked 213 White Ibis nests on northern Alley North, and several hundred more in Loxahatchee NWR's New Colony 3. Their nest success was quite high (54%, which is high for the species). Outside of the marked nests, nest success was apparently high in general for White Ibises, and we saw large groups of fledged and fledging young at Alley North and in Loxahatchee late in the season.

Wood Stork nests at Tamiami, Crossover and to some extent 3B Mud East were initiated in January and February. We monitored the fates of 90 marked nests at the Tamiami West colony, ENP, from 24 Feb—27 Apr 2006. The number of eggs per nest ranged from 1-5, with a mean of 3.12 (SE 0.008). The daily survival rate of eggs in marked nests was 0.992 (SE 0.0026) and the probability of a nest hatching at least 1 chick was 0.799. The number of hatchlings per nest ranged from 1-4 with a mean of 2.66 (0.009). The probability of a nest with hatched young fledging at least 1 chick (age 55 days) was 0.896. The combined probability of any nest start fledging at least one young for the season was 0.7153. Researchers at Everglades National Park estimated that there were approximately 400 nests at the Tamiami West colony—with a nest success rate of 0.7153 and 2.58 chicks fledging per nest, we estimate that around 740 wood stork chicks fledged from the colony this year. This was the best year for wood storks at Tamiami West since 2002. Although we did not follow marked nests at the 3B Mud East colony this year, aerial survey information suggests that this much smaller colony probably fledged about 1 chick per nest.

For all species, the timing of nesting was either typical or early, and nearly all fledged young during a time of year when the marshes were still drying, and food was highly available. This suggests that, unlike most years, young were fledged into an environment conducive to survival.

We compared aerial counts of nesting birds with counts in marked quadrats on the ground. For White Ibises in 2006, we found an overall error (total aerial – total ground/total ground) of 8.95%, or an overcount from the air. This represents the best estimate of the error in estimating the entire population. At individual colonies and quadrats, however, there was considerable variation (error of -24% to +11%), and the average of those values was an aerial undercount of 9.15%. This suggests that our best estimate of bias at any individual location may be to undercount by approximately 9%.

For Great Egrets, visual estimation error in 2006 and 2005 was somewhat larger, and more variable (- 21% to +72% in 2006, -60% - +9% in 2005) than for ibises. We generally found that aerial counts overestimated numbers of Great Egret nests in 2006, with the total error being approximately 25% and the average count error being 18.25%. The larger error is probably strongly affected by two factors. First, the presence of other light-colored species like Snowy Egrets typically offers a confusing picture to the observer, and we over-counted the most in quadrats where there was a high proportion of Snowy Egrets (2006-3, 2006-4).

We also measured population turnover within colonies for the purpose of using turnover to develop better estimates of total numbers of nest starts. We developed techniques during 2005 and 2006 for monitoring large numbers of individually identifiable nests using aerial photography. We took digital photographs of areas within colonies that were easily bounded by landscape features, and tallied individually identifiable nests over the course of many weeks during the nesting season. Four colonies were monitored during the 2005 and 2006 field seasons. In 2006, twenty six surveys were conducted between February 8th and the 12th of May in which repeated aerial transects allowed for the monitoring of more than 2000 Great Egret and 1000 White Ibis nests over time. In 2005, twenty-two surveys were conducted between March 1st and May 24th, allowing for the monitoring of approximately 1000 Great Egret and 500 White Ibis nests. Biweekly presence/absence data for individual nests were derived from aerial photographs, and these data will be used in a superpopulation modeling approach in order to develop better estimates of total numbers of nest initiations.

Weather and water conditions during 2006

> ***Rainfall.*** **The rainy season of 2004 was characterized by very low rainfall in June, followed by large amounts of rain in August, mostly from tropical storms and hurricanes. This left the system fairly full by the time of nesting. The spring was rainier than usual (Figure 1.18) with rainfall totals in January at or close to one standard deviation in excess of the monthly mean, and well in excess of that in February. The winter/spring rainfall events in spring 2005 were spaced closely enough that nesting cohorts that abandoned in response to one also experienced the next if they renested.**

In summer 2005, south Florida experienced considerably less rainfall than is typical, though this was largely made up in late summer (September and October) from hurricanes Rita and Wilma. The winter/spring of 2005/6 was drier or considerably drier than normal in every month except February. Thus the Everglades began the dry season (November) with normal to above normal water levels, and then had very little rain for the entire winter and spring.

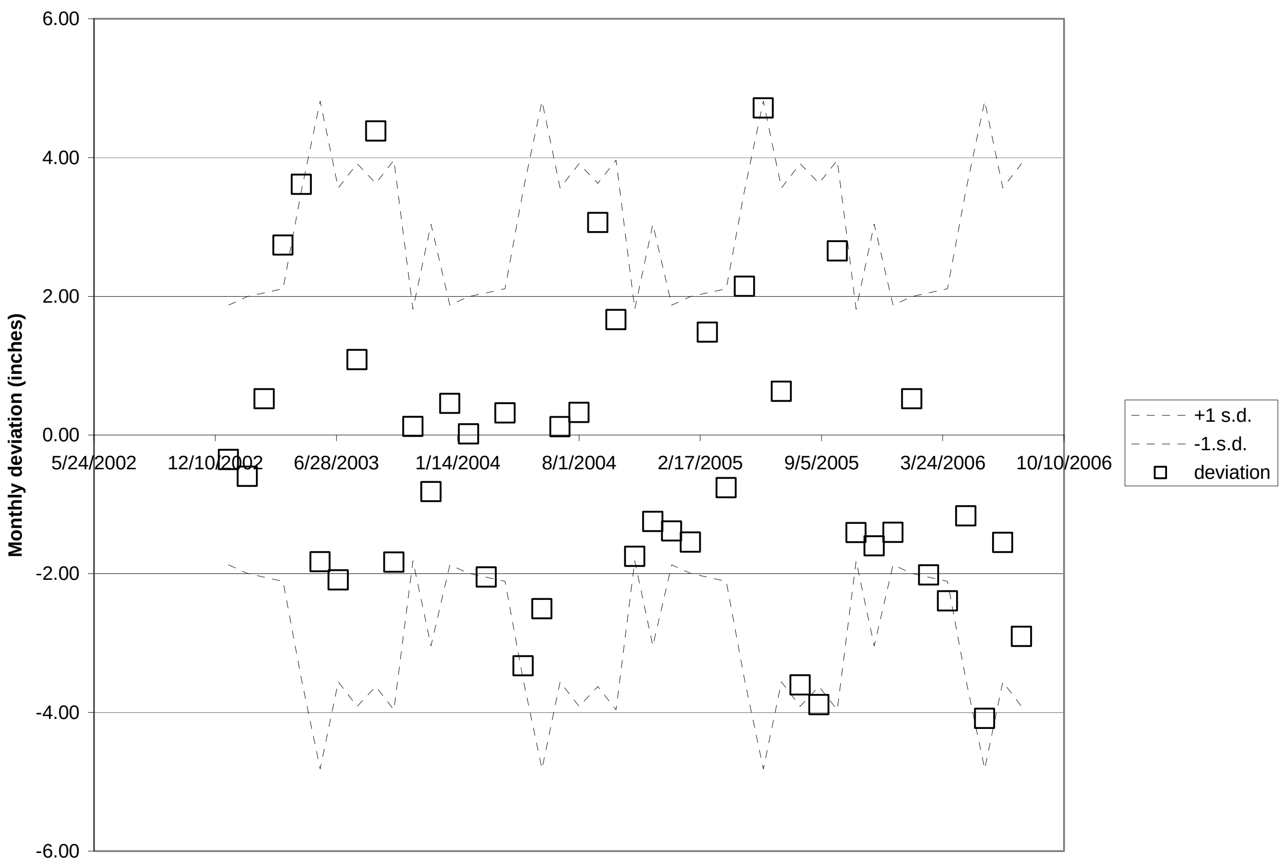

Figure 1.18. Deviations from mean monthly rainfall at 3A-S station in southern WCA 3A 2002 – 2006. Zero line indicates the mean monthly rainfall, solid fluctuating lines are one standard deviation

in excess or deficit of the mean deviations, and squares represent actual deviations in rainfall measured in each month.

Hydrology

As a result of late summer rainfall, the WCAs began the dry season (November) with high or very high stages than is typical for the season (Figures 1.19 and 1.20). This was followed by rapid drying throughout the season, with the exception of two rainfall events in February 2006, which caused temporary reversals in stage. Unlike in 2005, however, there were no major rainfall events in March or April, and the drying trend was essentially uninterrupted between late February and mid-May.

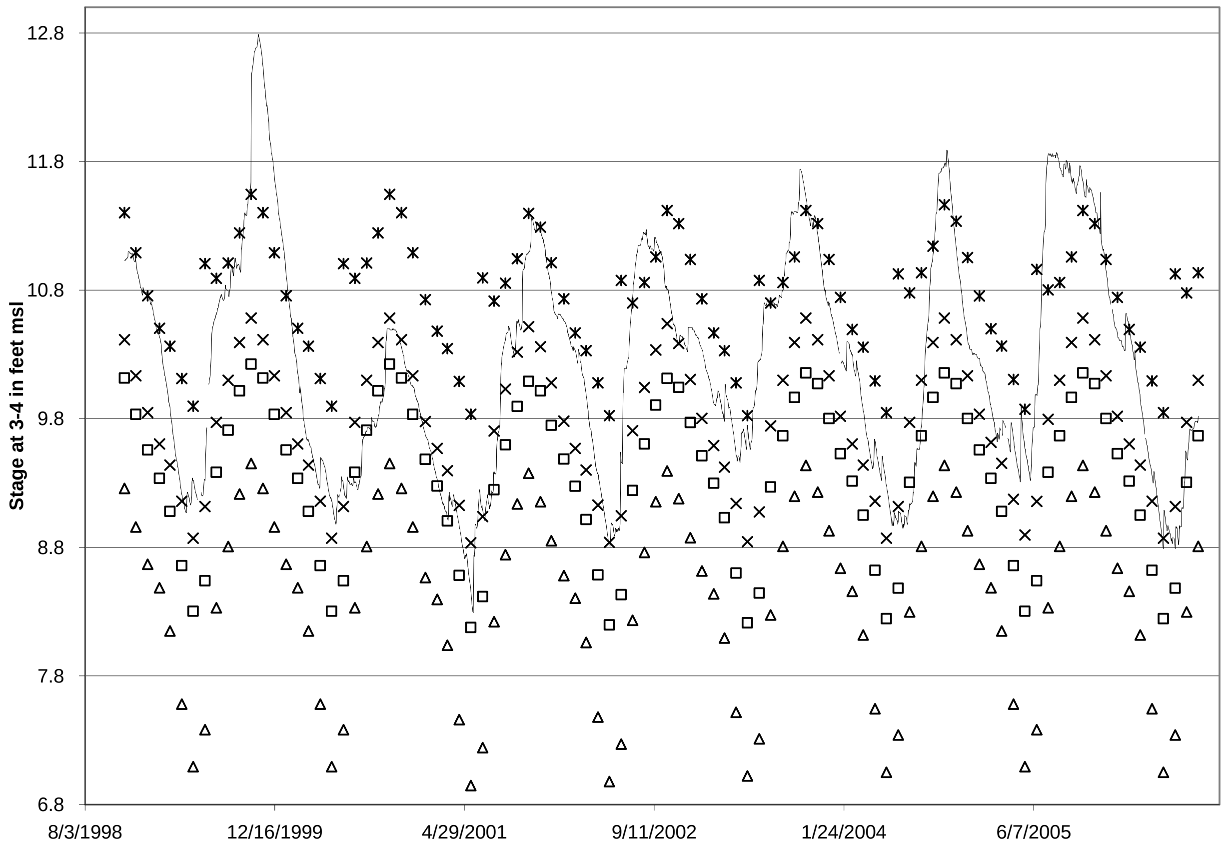

Figure 1.19. Stage at 3-4 Gauge in WCA 3, 2000 – 2006. Solid line indicates actual stage, x's are mean monthly maximum stage for the period of record, squares are mean monthly minimum stage for POR, asterisks are one standard deviation in excess of the mean maximum and triangles are one standard deviation below the mean monthly minimums.

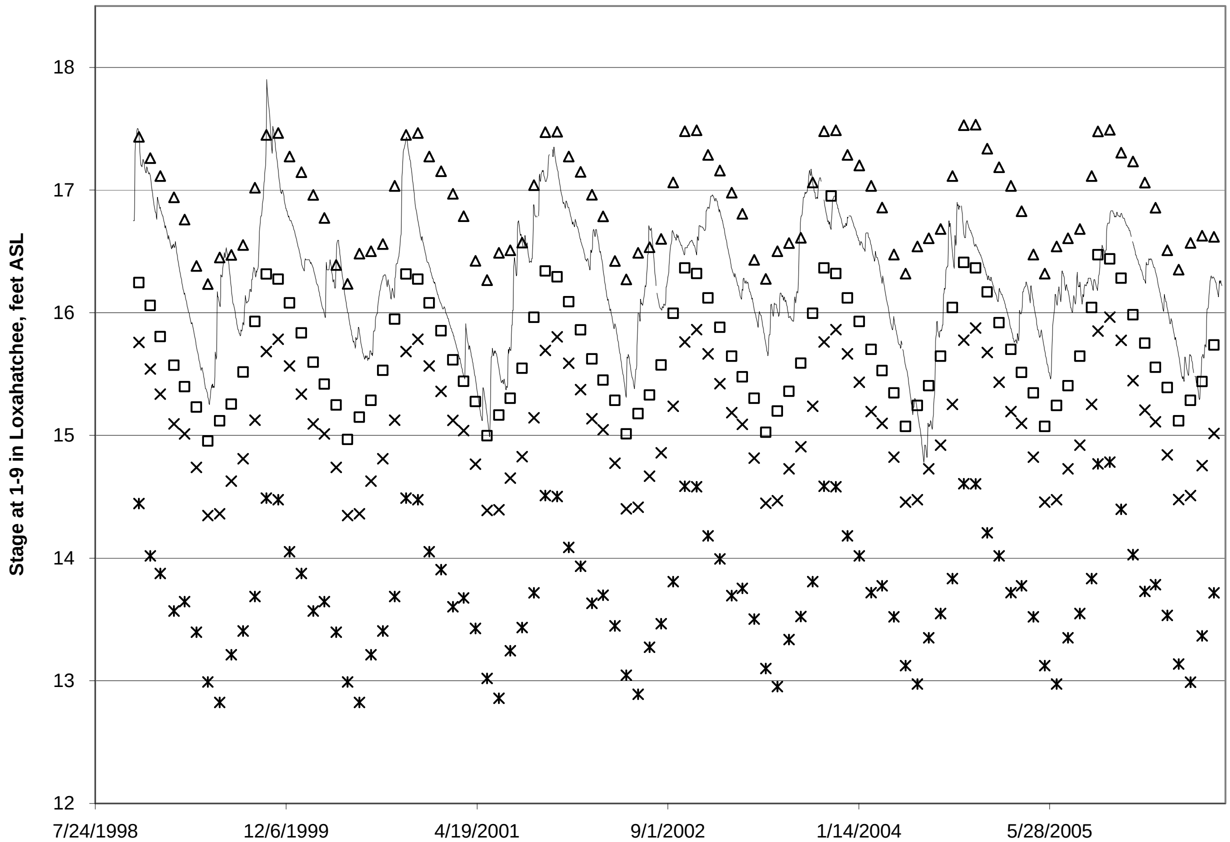

Figure1.20. Stage at 1-9 gauge in Loxahatchee National Wildlife Refuge (WCA 1), 2000 – 2006. Solid line indicates actual stage, squares are mean monthly maximum stage for the period of record, x's are mean monthly minimum stage for POR, triangles are one standard deviation in excess of the mean maximum and asterisks are one standard deviation below the mean monthly minimums.

In addition, the rainy season in June was slow to begin, with only sporadic rainfall in late May, which allowed water levels to remain constant or in some cases, to continue falling during early June. Regular rains and consequent increases in water level did not occur until the last week of June.

In the past, the behavior and reproductive response of birds has been thought to be predicted in part by the rate at which surface water recedes during the dry season (Kushlan et al. 1975, Frederick and Collopy 1989), as a result of both drainage and evapotranspiration. The mechanism of influence on the birds is through the concentration of prey animals on the marsh surface by the action of decreasing depths. This has been expressed as an early season recession rate (difference between monthly highs of November and January expressed as a per day rate) and a "late" recession rate (difference between monthly highs of January and March expressed as a per day rate). Note that a "fast" recession rate would be a high positive number, signifying rapid recession (2 mm/d and above), and a "slow" rate could be represented by negative numbers (stage actually increased between the two months).

Drying rates in 2006 were generally high, though there was considerable variation among water pools (Table 1.13). WCA 2a dried down quite rapidly during the entire season, with recession rates of 9 – 12 mm/d. In the context of this pool, these rates in early or late parts of the season have never been

exceeded. It seems likely that this recession rate created excellent early and late season feeding conditions for birds nesting in the northern Everglades.
In WCA 1 (Loxahatchee) drying rates were considerably slower, exceeding only 43% of years for the November – January part of the season, and 34% for the January – March part. WCA 3 was somehat intermediate, with rapid early drying rates exceeding 84% of records in the early part of the season, and less rapid rates that exceeded 49% of records in the late part of the season.

Table 1.13 Water level recession rates (mm/d) in the Water Conservation Areas, with comparisons of the year in question with historical records at each station. Note that negative values indicate rising water, positive values indicate falling water. Percent exceedance refers to the percent of years in the record in which the drying rate is less than that of the current year.

Year	Station	Early Dry	Late Dry	% Exceedance Early Drying Rate*	% Exceedance Late Drying Rate	% Exceedance Both Early and Late Drying Rate
2006	3-4	4.93	1.98	0.84	0.49	0.47
2006	1-9	1.52	1.24	0.43	0.34	0.09
2006	2A 1-7	12.08	9.82	1.00	1.00	1.00
2005	3-4	4.9	2.6	0.9	0.6	0.6
2005	1-9	8.5	-0.1	1.0	0.1	0.1
2005	2A 1-7	9.3	5.5	0.9	0.9	0.9
2004	3-4	5.18	2.19	90.2	53.7	53.7
2004	1-9	1.46	1.27	36.8	36.8	7.9
2004	2A 1-7	6.80	3.98	90.7	90.7	86.0
2003	3-4	0.400	1.524	22.5	37.5	20
2003	1-9	-3.690	2.573	2.7	62.2	0
2003	2A 1-7	3.146	1.559	69.0	50.0	33.3
2002	3-4	4.001	1.96	75.6	48.6	43.2
2002	1-9	9.26	1.54	0.975	47.5	45
2002	2A 1-7	3.27	0.723	0.806	22.2	16.7
2001	3-4	3.098	2.43	55.6	61.1	33.3
2001	1-9	4.347	1.16	91.4	28.6	22.9
2001	2A 1-7	6.246	2.32	92.3	94.9	89.7
2000	3-4	7.935	7.70	100	100	100
2000	1-9	4.54	na	94.1	na	
2000	2A 1-7	7.595	5.57	94.5	94.8	89.7
1999	3-4	2.13	3.83	41.7	91.7	38.9
1999	1-9	2.19	4.24	18	29	14
1999	2A 1-7	7.77	7.46	97.2	94.5	97.1
1998	3-4	-0.60	0.11	4.88	21.92	0.00

1998	1-9	1.48	-0.52	34.3	2.85	0
1998	2A 1-7	-4	-0.04	2.9	20	0
1997	3-4	2.63	1.419	57	42	36
1997	1-9	2.19	0.581	51.5	15.2	3.03
1997	2A 1-7	4.12	2.77	94.1	73.5	70.5
1996	3-4	6.99	5.68	100	100	100
1996	1-9	0.14	0.383	25.0	3.5	0.0
1996	2A 1-7	11.50	0.646	96.9	34.4	34.4
1995	3-4	-0.90	5.95	0.0	100.0	0.0
1995	1-9	0.97	0.21	32.1	10.7	3.6
1995	2A 1-7	0.55	3.50	28.1	87.5	29.0
1994	3-4	2.56	-1.08	58.6	6.9	3.6
1994	1-9	1.49	0.42	21.8	9.3	3.1
1994	2A 1-7	3.32	-4.67	90.0	3.3	3.3
1993	3-4	0.22	-0.40	10.0	10.0	3.3
1993	1-9	-0.33	3.91	14.8	7.8	0.0
1993	2A 1-7	-1.45	0.22	12.9	29.0	3.2
1992	3-4	2.29	2.63	24	38	14
1992	1-9	2.01	1.47	46	54	21
1992	2A 1-7	3.16	2.09	82.1	53.5	44.4

Based on data from the P-33 gage in Shark Slough (Figure 1.21), that drainage experienced moderately rapid drying rates in winter/spring 2005/6, exceeding 45% of years in the early rate, but only 15% of years in the late part of the season. The dry season began with stages high by comparison with historical records, and drying was interrupted only in February (first and last weeks). Unlike in the WCAs, water levels began rising in late May, and continued to do so throughout June. So the drying trend in ENP in 2006 was not extended as it was in the WCAs.

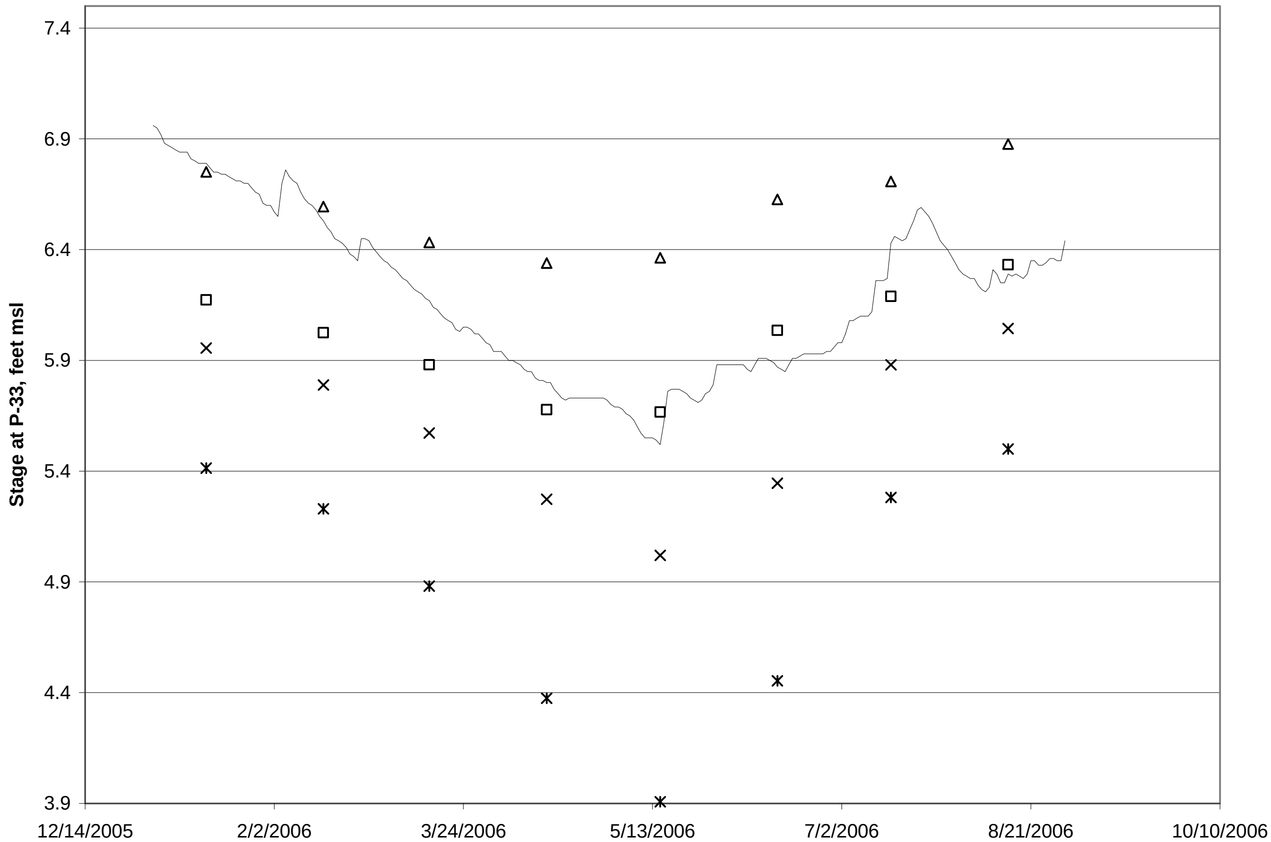

Figure 1.21. Stage at P-33 in central Shark Slough in Everglades National Park during 2006 spring. Squares represent mean monthly maximums, and x's mean monthly minimums, triangles are one standard deviation in excess of the monthly maximums, and asterisks are one standard deviation below the monthly minimums.

Methods

We performed two kinds of systematic surveys to document wading bird nesting in Water Conservation Areas 2 and 3 (and beginning in 2002, WCA 1) – aerial and ground surveys. These two kinds of surveys are complementary, and in the Everglades, neither does a good job alone (Frederick et al. 1996). The primary objective of both kinds of surveys is to systematically encounter and document nesting colonies. On or about the 15th of each month between January and June, we performed systematic aerial surveys for colonies, with observers on both sides of a Cessna 182, flight altitude at 800 feet AGL, and east-west oriented flight transects spaced 1.6 nautical miles apart. These conditions have been demonstrated to result in overlapping coverage on successive transects under a variety of weather and visibility conditions, and have been used continuously since 1986.
Once colonies were located, we noted position with an aircraft-grade GPS unit, with the airship positioned approximately over the north end of the colony, and estimated numbers of visible nesting birds while circling at a variety of altitudes (500 – 800 feet AGL). At small colony sizes (<100 nests), the proportional error in estimating numbers is generally small. However, as colony size grows beyond that, the bias is generally to underestimate numbers (Erwin 1982, Prater 1979), and controlled experiments with simulated counts have demonstrated both large bias (cf 40%) and large inter-

observer differences in bias (Frederick et al. 2003). In addition, the latter study also demonstrated that bias can be greatly reduced (by approximately half) through the use of counts of aerial photographs taken at the time of survey. For this reason, in this study digital photographs of the larger colonies were taken from overhead and multiple angles, and counted later via projection.

Due to the extremely large numbers of nests at the Alley North (= Rescue Strand) colony in the recent past (since 1998), we adopted some new techniques for estimating numbers of nests from the air. The majority of birds were nesting underneath the tree canopy, leading to a likely massive undercount using aerial estimation and photographic methods. We therefore counted the numbers of nests on the ground in quadrats of known size, and then compared these counts with aerial estimates of nests in the same area. The quadrats were marked on the ground with white paint on trees at the corners in such a way that they could be seen in photos taken from the air. This comparison allowed us to derive a correction factor to apply to the raw counts from aerial photos, in order to achieve an estimated total number of nests.

Systematic ground surveys of colonies by airboat were done between early April and late May, and were designed to locate and document small colonies or those of dark-colored species that are difficult to detect from aerial surveys. GPS-guided belt transects were generally in north-south orientations, and were also designed to give overlapping coverage. The width of belt transects varied between 0.5 nautical miles apart in WCA 3. Where islands were widely spaced, we could keep mental track of a wider field of view, and so the width of the belt transect would increase in order to maximize efficiency. All tree islands were approached closely enough to flush nesting birds, and nests were either counted directly, or estimated from flushed birds.

In the past, we have performed systematic, 100% coverage ground surveys of colonies by airboat in WCAs 1, 2 and 3 once between early April and late May. In 2005 and 2006, 100% coverage ground surveys throughout the WCAs were discontinued due to a change in MAP guidelines for monitoring (concentrating instead on measuring size and species composition of large colonies of white-colored waders). However, we did perform some systematic ground surveys in WCA 3 that allow for a direct comparison of densities of colonies in certain areas. This was designed to give an index of abundance for small colonies and dark-colored species in a fashion that might be sustainable.

It should be clear that this flushing technique works only for smaller colonies, since in large colonies the counting is much more difficult, and many of the birds in the interior would not flush.

We conducted ground surveys in late April and early May in 2006. The ground survey belt transects in WCA 3A extended from Tamiami Trail to I-75 (Alligator Alley). East/West boundaries are found in Table 1.14.

Table 1.14. East/West boundaries for Ground Survey transects, WCA 3A.

Transect #	Eastern Boundary	Western Boundary
1	80° 40.300’	80° 40.600’
2	80° 40.900’	80° 41.200’
3	80° 41.500’	80° 41.800’
4	80° 42.100’	80° 42.400’
5	80° 42.700’	80° 43.000’
6	80° 43.300’	80° 43.600’
7	80° 43.900’	80° 44.200’
8	80° 44.500’	80° 44.800’
9	80° 45.100’	80° 45.400’

10	80° 45.700’	80° 46.000’
11	80° 46.300’	80° 46.600’
12	80° 46.900’	80° 47.200’
13	80° 47.500’	80° 47.800’
14	80° 48.100’	80° 48.400’
15	80° 48.700’	80° 49.000’
16	80° 49.300’	80° 49.600’

The large colonies were generally few in number and were counted by a combination of aerial survey estimation and photo-counts for white-colored species (as above), and walk-through counts. An example of how these techniques are combined is shown by the “Hidden” colony (also called in previous years “L-28”, and “40-mile bend”) located in extreme southwestern WCA 3. This colony has substantial numbers of Great Egrets, and large numbers of Snowy Egrets, Tricolored Herons, Anhingas and Little Blue Herons. The colony is largely in dense cypress woods, and visibility from the ground is limited to tens of meters. The Great Egrets and Snowy Egrets are typically counted from aircraft at what was perceived to be their maximum density during incubation periods (February or early March for GREG, late March or April for SNEG). The Tricolored Herons, Anhingas and Little Blue Herons were systematically counted during incubation stage on foot, using 3 – 6 observers walking abreast, spaced 5 – 15 m apart along compass lines. Nests of the three small herons (Snowies, Tricoloreds and Little Blues) are indistinguishable unless chicks are present. Generally, Snowy Egrets nested in groups that were discernable as the birds flushed. Where chicks were not present, we estimated species proportions of nests based on numbers of birds flushed from particular areas.
As part of an effort to measure nest turnover in colonies, we also estimated nest success in several colonies, by repeatedly recording the contents and fates of marked nests. This was done both on the ground and from the air, using digital photos with landmarks that allowed the repeated identification of individual nests. We established aerial and ground-based belt transects in Alley North, Vacation, Vulture, Yonteau and Cypress City colonies early in the nesting period and (on the ground) marked active nests within a designated distance from the center of the transect. We then returned every 5-7 days to walk transects and check the progress of those nests, count failures and add new nesting attempts to the transect. Nest success was expressed using Mayfield’s method for pro-rating survival on a daily basis.

Determining optimal transect widths in ENP and BICY

We began an investigation to determine optimal transect widths for systematic wading bird survey flights conducted in mangrove and cypress environments. The basic method for determining transect spacing is to measure lateral detection distances for naive observers. To do this requires active colonies in natural vegetation. There were no colonies of note in Big Cypress National Preserve at the time of testing, but 3 test flights were conducted between 31 May to 7 June 2005 at 8 known mangrove colonies in the western and southwestern regions of ENP. One “informed” and two naive observers flew past colonies at progressively shorter lateral distances to assess detection probabilities. Additional test flights and subsequent analyses are scheduled for the 2006 season.

Results

Nesting Effort. Combining all species at all colonies in LNWR, WCA 2, and WCA 3, we estimated a grand total of 39,677 wading birds (Cattle Egrets, Anhingas and cormorants excluded) were initiated between February and July of 2006 in the WCAs (Table 1.15). Note that this figure does not include birds nesting at the Tamiami West and East colonies; although we monitored these colonies, they are technically part of Everglades National Park.

	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLIB	CAEG	a t
ahatchee R	1800	5194	0	0	3	30	30	3745	50	0	0	50	0	1
A 2 &3	5697	15698	190	850	328	561	289	4540	1212	40	28	192	00	2
WCAs	7497	20892	190	850	331	591	319	8285	1262	40	28	242	00	3

Table 1.15. Total numbers of nests initiated in WCAs 1, 2, and 3 during February through June 2006. Totals do not include numbers of Anhingas or Cattle Egrets. See also Tables 1.18 and 1.19, and Appendices 1.5 and 1.6 for more details.

The 39,677 figure for 2006 represents a substantial 63% increase over the 2005 total of 24,248 obtained using the same methods. As stated above, this is a conservative estimate, especially considering that a sizeable upsurge in nesting took place at the Hidden colony where a large portion of birds were obscured by cypress cover.

Estimates for breeding seasons prior to 2005 are based on complete ground survey coverage (which we have not done in 2005 or 2006) and so truly direct comparisons of total numbers of nest starts of all species cannot be made. However, because ground surveys have historically contributed about 30% of the total numbers, we might speculate that a comparable wading bird total would be achieved by increasing this year's aerial survey numbers of 38,986, by 43% (70% x 1.43 =100%) yielding 55,750. However, this is a very rough estimate and should be used only to reinforce that the total numbers of nesting pairs in 2006 were similar to, if not slightly exceeding the averages of the past five years.

We can also directly compare years by comparing numbers of species that have always been counted primarily by aerial methods (White Ibises, Snowy Egrets, Great Egrets). Numbers of ibis nests in '06 were quite similar to the average of the previous five years (within 5%), and 45% greater than the average of the previous ten years. Great Egrets were also similar to the average of the previous five years, and considerably larger than the average of the last ten. Snowy Egrets were the real surprise, with 76% more nests than the average of the last five years, and nearly three times that of the last ten. This continues a trend of rapid increases in nesting numbers for Snowy Egrets in recent years, dominated Alley North and Hidden colonies.

Ground surveys (which largely ignore exclude larger, white-wader colonies visible from the air) yielded a total of 691 wading bird nests (169 locations averaging 4.1 nests per location) in the area surveyed. When Anhingas are included in the totals, we found 1121 nests (190 locations, 5.9 nests per location). These totals represent a 280% (wading birds only) and 108% increase (all nests including Anhingas) over the 2005 totals from the same area, respectively. The number of wading bird nesting locations this season in the ground surveys increased by nearly 66% over 2005 while all nesting (including ANHI) locations decreased slightly, about 6%. Average nests per location showed a modest increase of 16% over that of the 2005 figure of 5.1 nests per location.

By comparison with other years in which surveys have been carried out within the same transects in WCA 3 (1996 – 2005), we found 40% more Anhingas, 200% the Great Blue Herons, 75% more Tricolored Herons, three times the Black-crowned Night Herons, and 35% fewer Little Blue Herons in 2006 (Figure 1.22). In 2005, we found 40% more Anhingas than on average, 19% more Great Blue Herons, 80% fewer Tricolored Herons, three times the Black-crowned Night Herons, and 85% fewer Little Blue Herons.

These comparisons can be used to some extent to guess at how many total birds might be in WCA 3 (as if we had done 100% coverage ground surveys). However, they probably cannot be used as anything more than guesses, since there likely to be considerable spatial variation in distribution of nests from year to year.

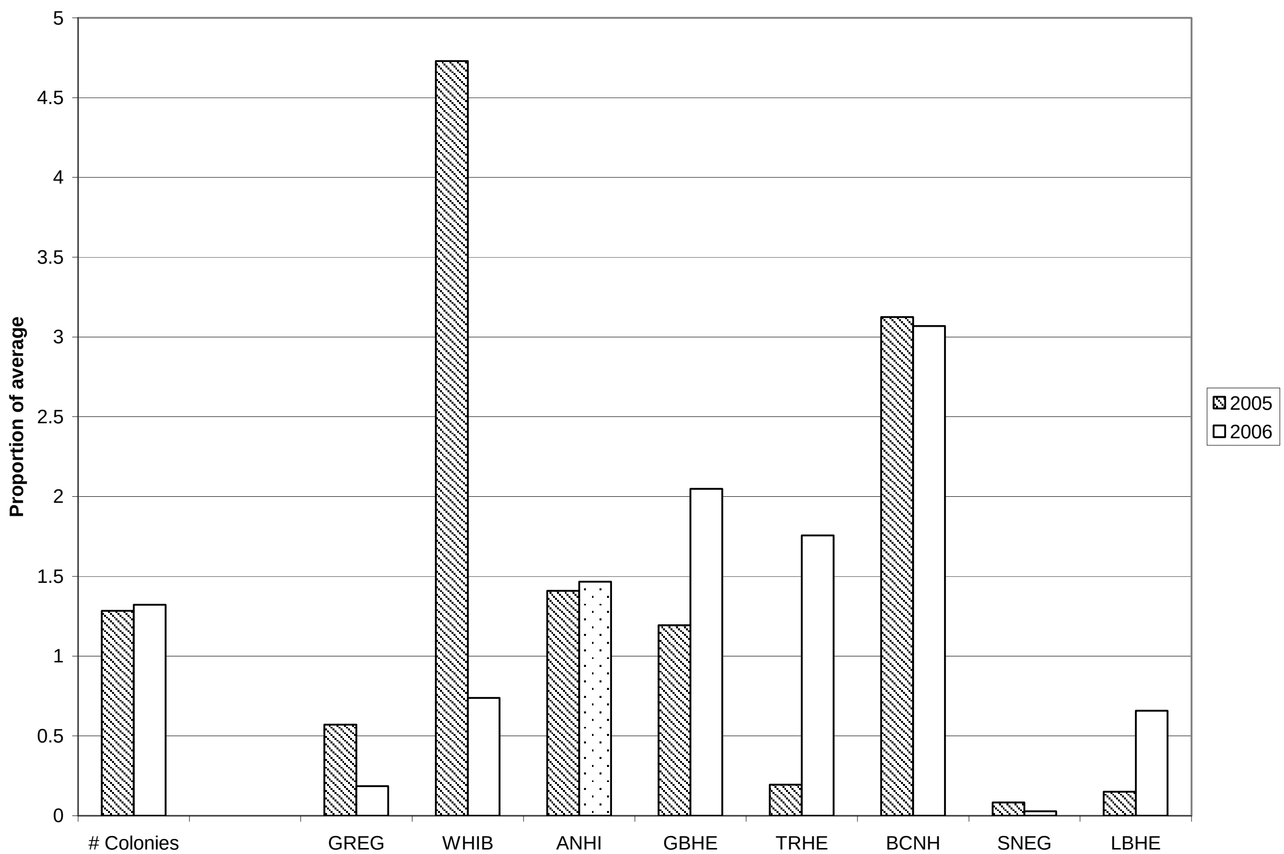

Figure 1.22. Nests and colonies discovered on systematic ground surveys in 2005 and 2006, as a proportion of the average numbers found in the same survey area in 1996 – 2005. Proportions greater than one indicate that the year was above average in that metric.

Nest count estimation

In addition to regular monitoring of nesting through both ground and aerial surveys, we are in the process of developing better counting and estimation methods. One of the possible sources of error is the bias introduced by vegetation and other occlusion of nests from aerial observers. To estimate this error, we have repeatedly counted numbers of nests from the air and the ground in large areas (cf 1000 m^2). In 2005 and 2006, we established seventeen quadrats in colonies in WCA-3A and WCA-1. Within 36 hours of each marked quadrat being established, all nests within the quadrat were counted on the ground and then surveyed aerially. According to ground counts, in 2005 a total of 95 Great Egret nests were surveyed (see chapter on 2005 results for WCAs). In 2006, a total of 2402 nests were included in these quadrats (2212 White Ibis nests, 69 Great Egret nests, 82 small heron nests of various species, 1 Snowy Egret nest, 16 Night Heron nests of both species, 17 Glossy Ibis nests, 4 Roseate Spoonbill nests, and 1 Great Blue Heron nest (see Tables 1.15 and 1.16).

For White Ibises in 2006, we found an overall error (total aerial – total ground/total ground) of 8.95%, or an overcount from the air. This represents the best estimate of the error in estimating the entire population. At individual colonies and quadrats, however, there was considerable variation (error of -24% to +11%), and the average of those values was an aerial undercount of 9.15%. This suggests that our best estimate of bias at any individual location may be to undercount by approximately 9%. However, this may be misleading, since many of the variables that probably influence aerial count accuracy at the level of a small quadrat (presence of other species, degree of cover) may well be integrated by observers when estimating over an entire colony. It is probably truest to say that our error in estimating ibis nests is probably bounded by the negative to positive 9% values suggested by both total and colony error estimates.

Table 1.15. Comparison of nests counted from aircraft and ground in quadrats of known size during 2005, with percent error (aerial – ground/ground).

2005

Quadrat #	Date	Species	Ground Count	Aerial Count	% Error	Cover	Colony
2005-1	3/20/05	GE	23	20	-13	low	Alley North
2005-2	3/20/05	GE	54	21	-61	medium	Alley North
2005-3	3/20/05	GE	10	11	9	high	Alley North
2005-4	3/26/05	GE	8	4	-50	low	Alley North
Total % error				-41.05			
Average % error				-28.75			

Table 1.16. Comparison of nests counted from aircraft and ground in quadrats of known size during 2006, with percent error (aerial – ground/ground).

Quadrat #	Date	Species	Ground Count	Aerial Count	% Error*	Cover	Location
2006-1	3/17/2006	GE/mixed	GE 14 SH 35	GE 12 SNEG 19	-14	High	Alley North
2006-2	3/17/2006	GE/mixed	GE 24 SH 7 SNEG 1	GE 19 SNEG 6	-21	High	Alley North
2006-3	3/29/2006	GE/mixed	GE 5 SH 19	GE 18 SNEG 6	72	High	Alley North
2006-4	3/29/2006	GE/mixed	GE 16 SH 18	GE 25 SNEG 10	36	High	Alley North
2006-5	3/29/2006	WHIB	205	173	-16	Low	Alley North
2006-6	4/7/2006	WHIB	72	69	-4	Low	Alley North
2006-7	4/14/2006	WHIB	33	30	-9	Low	Alley North
2006-8	4/14/2006	WHIB	30	24	-20	Medium	Alley North
2006-9	4/17/2006	WHIB	18	20	10	Medium	Alley North
2006-10	4/17/2006	WHIB	67	73	-8	Medium	Alley North
2006-11	4/21/2006	WHIB	WHIB 414 SH 1	WHIB 467	11	Medium	New Colony 3
2006-12	4/21/2006	WHIB	WHIB 445 BCNH 12	WHIB 491	9	Low	New Colony 3
2006-13	4/26/2006	WHIB	WHIB 139 ANHI 1 BCNH 1 YCNH 1	WHIB 113	-19	Medium	New Colony 3
2006-14	4/26/2006	WHIB	303	253	-17	Medium	New Colony 3
2006-15	4/26/2006	WHIB	WHIB 96	WHIB 73	-24	High	New Colony 3

			SH 2				
2006-16	5/3/2006	WHIB	WHIB 390	319	-19	Medium	New Colony 3
2006-17	5/3/2006	WHIB	WHIB 114	99	-13	Medium	New Colony 3

* Calculated for GE or WHIB only.

	Total ground	Total aerial	total percent error	Average percent error
Overall WHIB	2023	2204	8.94711	-9.15385
Overall GE	59	74	25.4237	18.25

For Great Egrets, visual estimation error in 2006 and 2005 was somewhat larger, and more variable (-21% to +72% in 2006, -60% - +9% in 2005) than for ibises. We generally found that aerial counts overestimated numbers of Great Egret nests in 2006, with the total error being approximately 25% and the average count error being 18.25%. The larger error is probably strongly affected by two factors. First, the presence of other light-colored species like Snowy Egrets typically offers a confusing picture to the observer, and we over-counted the most in quadrats where there was a high proportion of Snowy Egrets (2006-3, 2006-4). This effect may also explain the large difference between 2005 and 2006 error estimates – in 2005 we had no quadrats in which Snowies were nesting with Great Egrets. Thus the tendency may be to undercount Great Egret nests from the air when they are nesting alone, and to overcount when they are nesting with Snowy Egrets (or perhaps other similarly sized white birds). The second effect probably applies to both years. The relatively small number of Great Egret nests found within any quadrat means that low sample size probably exerts an influence on the measurement of any accuracy estimate.

We also measured population turnover within colonies for the purpose of using turnover to develop better estimates of total numbers of nest starts. To do this accurately, we needed large numbers of nests spread over both space (geographically and within some of the larger colonies) and time (within the nesting season). While these data can be obtained from ground based repeated surveys of marked nests, the number of nests and transects is quite limited. We developed techniques during 2005 and 2006 for monitoring large numbers of individually identifiable nests using aerial photography. We took digital photographs of areas within colonies that were easily bounded by landscape features, and tallied individually identifiable nests over the course of many weeks during the nesting season.

Four colonies were monitored during the 2005 and 2006 field seasons. In 2006, twenty six surveys were conducted between February 8th and the 12th of May in which repeated aerial transects allowed for the monitoring of more than 2000 Great Egret and 1000 White Ibis nests over time. In 2005, twenty-two surveys were conducted between March 1st and May 24th, allowing for the monitoring of approximately 1000 Great Egret and 500 White Ibis nests. Biweekly presence/absence data for individual nests were derived from aerial photographs, and these data will be used in a superpopulation modeling approach in order to develop better estimates of total numbers of nest initiations. At the time of writing, we have tallied turnover by Great Egrets and are beginning the same for White Ibises.

Nesting Success

Nesting success was markedly higher for all species in 2006 than in 2005. We marked a total of 275 Great Egret nests but, because limited access later in the season (due to a persistent and rapid dry-down) we were able to follow only 233 to the end of their nesting cycle. We found the inter-colony average probability of a nest start resulting in large young in 2006 was 75% compared to 17.6% last year (Mayfield success) with an average number of young fledged per nest slightly over 2.5 (see Table 1.17). Small heron nests (Snowy Egrets, Tricolored Herons, Little Blue Herons), were similarly successful, with an interspecific average probability of success of 80% (21% in 2005) and an average of 3.2 chicks fledged per nest. Note that Tricolored Herons and Snowy Egrets, where measured in the Alley North colony, showed 100% nest success.

We marked 213 White Ibis nests on northern Alley North, and several hundred more in Loxahatchee NWR's New Colony 3. Due to the later initiation dates in the latter location, most could not be followed over the entire extent of their nest cycles. Still, based on our observations in the early and middle stages, we believe that their nest success was quite high (54%, which is high for the species). Outside of the marked nests, nest success was apparently high in general for White Ibises, and we saw large groups of fledged and fledging young at Alley North and in Loxahatchee late in the season.

Wood Stork nests at Tamiami, Crossover and to some extent 3B Mud East were initiated in December and January, which represents a marked change from the typical January and February initiation. We monitored the fates of 90 marked nests at the Tamiami West colony, ENP, from 24 Feb—27 Apr 2006. Nests were visited weekly and eggs and chicks were counted using mirror poles. We used a maximum likelihood approach (Program MARK) to estimate the daily survival rates of eggs and chicks. The number of eggs per nest ranged from 1-5, with a mean number of 3.12 (SE 0.008). The daily survival rate of eggs in marked nests was 0.992 (SE 0.0026) and the probability of a nest hatching at least 1 chick was 0.799. The number of hatchlings per nest ranged from 1-4 with a mean of 2.66 (0.009). The daily survival rate of chicks from marked nests from hatching to up to 49 days of age was 0.998 (0.0009) and the probability of a nest with hatched young fledging at least 1 chick (age 55 days) was 0.896. The combined probability of any nest start fledging at least one young for the season was 0.7153. Researchers at Everglades National Park estimated that there were approximately 400 nests at the Tamiami West colony—with a nest success rate of 0.7153 and 2.58 chicks fledging per nest, we estimate that around 740 wood stork chicks fledged from the colony this year. This was the best year for wood storks at Tamiami West since 2002. Last year (2005) all marked nests (59) had failed by early April and it was estimated that only 20-25 of 200 nest starts were successful. In 2004, approximately 50 pairs initiated nests at Tamiami West, but all abandoned following heavy rains in early March. Although we did not follow marked nests at the 3B Mud East colony this year, aerial survey information suggests that this much smaller colony probably fledged about 1 chick per nest.

For all species, the timing of nesting was either typical or early, and nearly all fledged young during a time of year when the marshes were still drying, and food was highly available. This suggests that, unlike most years, young were fledged into an environment conducive to survival.

Table 1.17. Nest success information for Great Egrets (GE) White Ibises (WHIB), Snowy Egrets (SNEG), Little Blue Herons (LBHE), Tricolored Herons (TCHE) and Black-crowned Night Herons (BCNH) nesting in WCAs 1, 2 ,and 3 in 2006. K = numbers of nests followed, Y = number of nests successful, T = number of nest-days, p = daily nest success, v = variance of p, j = number of days in each nesting period, pj = period success, vj = variance of pj, P = overall nest success, and V = variance of P.

Colony	Species	Period	K	ΣY	ΣT	p	v	j	Pj	vj	P	V
AN	GE	Incubation	50	37	591	0.978003	3.64E-05	28	0.536451	0.008586		
AN	GE	Nestling	47	44	965.5	0.996893	3.21E-06	21	0.936737	0.001249	0.502513	0.007904
AN	SH	Incubation	24	9	305	0.95082	0.000153	22	0.329731	0.008924		
AN	SH	Nestling	5	4	48.5	0.979381	0.000416	14	0.74701	0.047476	0.246312	0.010565
AN	WHIB	Incubation	220	156	2289	0.97204	1.19E-05	21	0.551275	0.001684		
AN	WHIB	Nestling	139	138	717.5	0.998606	1.94E-06	14	0.980664	0.000367	0.540616	0.001732
AN	GLIB	Incubation	10	9	78	0.987179	0.000162	21	0.762638	0.042706		
AN	GLIB	Nestling	9	9	95	1	0	14	1	0	0.762638	0.042706
AN	LBHE	Incubation	20	20	328	1	0	22	1	0		
AN	LBHE	Nestling	22	21	305.5	0.996727	1.07E-05	14	0.955136	0.001922	0.955136	0.001922
AN	SNEG	Incubation	11	11	171.5	1	0	22	1	0		
AN	SNEG	Nestling	15	15	199	1	0	14	1	0	1	0
AN	BCNH	Incubation	8	8	158	1	0	28	1	0		
AN	BCNH	Nestling	9	9	184	1	0	21	1	0	1	0
AN	TCHE	Incubation	12	12	216	1	0	22	1	0		
AN	TCHE	Nestling	14	14	196	1	0	14	1	0	1	0
HENRY	GE	Incubation	20	18	307	0.993485	2.11E-05	28	0.832762	0.011613		
HENRY	GE	Nestling	28	26	537.5	0.996279	6.9E-06	21	0.924701	0.00262	0.770056	0.011778
CYPCITY	GE	Incubation	50	41	781	0.988476	1.46E-05	28	0.722862	0.006115		
CYPCITY	GE	Nestling	36	35	400.5	0.997503	6.22E-06	21	0.948854	0.002482	0.685891	0.006817
VACISL	GE	Incubation	55	52	957	0.996865	3.27E-06	28	0.915841	0.002161		
VACISL	GE	Nestling	48	47	882.5	0.998867	1.28E-06	21	0.976472	0.000541	0.894293	0.002515
VULTURE	GE	Incubation	79	75	1560.5	0.997437	1.64E-06	28	0.930657	0.001118		
VULTURE	GE	Nestling	80	77	1524	0.998031	1.29E-06	21	0.959465	0.000525	0.892933	0.001485

Table 1.18. Numbers of nest initiations in colonies in WCAs 2 & 3 during 2006. See Appendix 1.5 for locations and colonies with fewer than 50 nests. Asterisks denote colonies where reproductive success was monitored intensively.

Colony name	WCA	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLIB	CAEG	Colony total
Alley North**	3	1,193	13,566		200	22	320	214	3,000	470	40	20	190		19,035
Hidden	3	300	1,868												2,168
	3	215				5			694						914
3B Mud East	3	256	203	15					200						674
Vulture**	3	378				1			80						459
Big Mel	3	318							89						407
	3	120				2			200						322
Crossover	3	140		175											315
6th Bridge Island	3	200				12									212
	3	204													204
Cypress City**	3	173			60	8									181
	3		16			4				157					177
Vacation **	3	120			45	6	10	5	35						176
	2	57							85						142
	3									138					138
2B Melaleuca	2	134													134
	2	116													116
	3	114													114
	3	8					50			55					113
Yonteau	3	113													113
	3	85				2									87
	3	81													81
	3						80	1							81
Little D	3	80			80										80
	3									80					80
	3	70													70
	3	65													65

	3	62				2									64
	3					2			60						62
	3	61													61
	3	56				4									60
Henry **	3	55			35	1									56
	3	56													56
	3	52													52
Colonies with < 50 pairs		815	45	0	430	257	101	69	97	312	0	8	2	0	1,706
Totals		5,697	15,698	190	850	328	561	289	4,540	1,212	40	28	192	0	28,775

Table 1.19. Numbers of nest initiations in Loxahatchee National Wildlife Refuge during February through June 2006.

	WCA	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLIB	CAEG	Total
New Colony 3	1		4,800					30	200				50		5,080
	1	437							1,600						2,037
Lox 99	1	1,136							900						2,036
	1	73	200						140						413
	1								397						397
	1	108	194												302
	1								177						177
	1								100						100
	1								81						81
	1						30			50					80
	1								60						60
	1					3			50						53
	1	33													33
	1								28						28
	1								12						12
	1	7													7

	1	6														6
totals		1,800	5,194	0	0	3	30	30	3,745	50	0	0	50	0		10,902

Optimal width of survey transects in the mangrove environment.

Our preliminary tests reveal substantial variation in the ability of both naïve and informed observers to detect wading bird colonies in mangroves (Table1.20). Some of the smaller wading bird colonies were never detected by naïve observers, even the were flown almost directly over them. When detected, detection distances appeared to be as low as 0.4 nautical miles. Colony size, species composition, cloud cover, and direction all appear to play a role, though our sample size is not large enough to detect statistically significant effects of these factors. In addition, it should be noted that these preliminary detection distances are for white colored species only.

Table 1.20. Preliminary results for colony detection of white plumaged wading birds during aerial surveys in mangrove habitat. All detection distances are in nautical miles (nm).

Colony Size	Dominant Species	Distance of first detection by informed obs. (nm)	Distance of first detection by naive observers (nm)
450	SNEG	0.6	0.6
105	WHIB	1.0	1.0
100	GREG	1.2	1.0
90	GREG	0.6	0.2
75	WHIB	0.4	not
75	WHIB	0.8	not
35	SML WH	0.8	0.8
5	WOST	0.6	not

<u>Discussion</u>

The numbers of nesting wading birds met the criteria for restoration only for Great Egrets and White Ibises – all others fell below or well below the targeted 5-year running average goals. In addition, there was no indication that storks were moving into the coastal region of Everglades National Park, nor that they had any inclination to nest earlier in the year. This is somewhat surprising, since the early drying trends were quite favorable in most parts of the system, and extremely favorable in some (90^{th} percentile in some of the WCAs). As above, large numbers of birds were attracted to the south Florida ecosystem, so the numbers of potential nesters did not seem to be the issue. So there appeared to be something missing from the suite of conditions necessary to cue early nesting. It may be significant however, that several of the historical colonies or historical regions of colonies in coastal ENP were occupied by small numbers of birds both this year and last – this trend may be indicative of building use of the area, which is one of the criteria in the CERP for healthy wading bird nesting.

Summary of nesting in 2005.

The poor nest success and abandonment throughout the region seemed rather clearly to be related to unseasonable weather rather than any particular management pattern, especially since the effects were uniform throughout the region. In the context of the longer term history of nesting, however, the numbers of initiations in this year of poor conditions may be seen as remaining well above the average of the past 20 years. A large increase in total nesting numbers occurred in about 1999, and appears to be persistent, even in the face of poor nesting conditions like 2005. This suggests that something relatively permanent has occurred to boost the baseline level of nesting.

Nesting in the previous several seasons in the central Everglades has been unusually large and successful for most species, and it is possible that the large numbers that nested in 2005 despite poor conditions were a result of short-term philopatry (tendency to return to previous nesting, in this case possibly because of prior nesting success). It seems numerically impossible for the large numbers of birds in 2005 to have been the result of local recruitment from previous years, and instead it seems more likely they were adult birds returning to nest. During late 2002, the drought in the southeastern U.S. had broken, and wetlands in most southeastern states became rehydrated, opening up opportunities for nesting waders that had not existed during the drought years of 2000 – 2002. The large and persistent nesting aggregations in the Everglades 1999 – 2005, despite the early season weather and the existence of these other places for nesting, seems to emphasize a certain degree of philopatry as an explanation for the 2005 event. Although varying degrees of philopatry have certainly been noted before for herons and storks (Frederick 2001), there has been almost no evidence of philopatry noted before for ibises (Kushlan and Bildstein 1992, Frederick and Ogden 1998). However, this may be because ibises are usually compared as a species with other species that are generally more philopatric.

The magnitude of possible undercount, especially for ibises, is of interest to managers and scientists alike. On the one hand, this seems to present little real difficulty in comparisons with past years and surveys, simply because those past years must have been susceptible to the same potential for bias and undercount. On the other hand, the bias stems from ibises nesting underneath the canopy, which seemed to be exaggerated by comparison with the past ten years at one of the major colonies (Alley North). Of course, its unknown whether the degree of nesting under the canopy (with resulting underestimation) has been as much or more of a problem in counts prior to the 1990's; considering the range of colony vegetation types, it probably has been at some time. So it is clear that the 2005 count of ibises is an undercount of some large magnitude, but whether this matters or not in the larger picture of nesting during the past century is unknown. The lesson from this frustration is that we should continue to estimate the bias in our counts, and do so consistently in the future. As long as the raw estimates are also preserved, there is no tradeoff with being able to compare directly with past counts.

Analysis of nesting effort and success during 1999 – 2006.

The dramatic changes in nesting effort during the period 1999 – 2005 were large enough and sufficiently unprecedented to demand explanation, even if the explanations are partly speculative. The period of 1994 – 1997 was one of generally high water conditions, during which very few storks, ibises, or Snowy Egrets nested, and both numbers and nesting success of Great Egrets and Great Blue Herons increased. During this time, there were no years in which large portions of the marsh surface dried, at least within WCAs 3, 2, and the southern half of WCA 1. In contrast, the marsh surface was considerably drier during the period 1999 – 2001, with only about half the WCAs being wet by May of 2000 and 2001, and slightly more during 1999. Nonetheless, this idea of drier conditions is only by comparison with the very wet conditions of the mid-1990's. Neither stage nor rainfall during 2000 and 2001 could be considered low by comparison with long-term records, and in most water management units, stages were high to normal.

Nesting effort of storks (Kushlan et al. 1975) and ibises (Frederick and Collopy 1989) has been linked in a statistical way with the rapidity of drying of the marsh surface. This correlation between nesting effort and drying rate certainly held true for the period of 1998 – 2001. In 1998, water levels were high and drying rates low, and nesting effort was the lowest of the four years. Drying rates were substantially higher in 1999, 2000 and 2001, with nesting increasing almost in direct proportion to the drying rate. Although drying rate is therefore correlated with nesting effort during the study period, there may be other important factors that led to the high nesting effort in 1999 – 2005.

First, there is evidence that drying rate alone is a poor explanation for nesting effort in many other years in the record. During 1995, for example, drying rate was virtually the highest on record in many WCAs, yet a very poor nesting year ensued; this was a very high water year, however, and despite the rapid drying, surface water was still quite deep by the middle of the nesting season. Similarly, during 1988, 1989 and 1990, drying rates were extremely rapid, yet little or no nesting occurred in these years. These were years in which most or all of the marsh surface dried during the spring and early summer, and although drying was fast, there was apparently too little water to support foraging for very long in most areas. Thus rapid drying apparently must be accompanied by water levels that are neither extremely deep, nor extremely shallow over much of the marsh. It is possible that the rapid drying of the 2000 and 2001 seasons was accompanied by water levels at or close to some optimum in this regard. In any event, drying rates by themselves can only explain a small proportion of variation in annual numbers of nests (cf 20%).

The effect of antecedent drought conditions on fish community dynamics and fish abundance is another possible explanation for the nesting pattern observed. This theory suggests that some aspect of drought conditions causes a flush of exceptionally high densities of small "forage" fishes. Although the mechanism is unclear, the predicted pattern of exceptionally large nestings immediately following the cessation of droughts has been well supported by the historical nesting record (Frederick and Ogden 2003). However, the 2000 - 2005 nesting seasons did not conform to the predictions of this hypothesis. The nesting events in 2000, 2001 and 2002 qualified as exceptionally large nestings in the context of recent history, yet none was preceded by any exceptionally strong drying event. Instead, these years were preceded by an exceptional period of high water (1994 – 1997), with less exceptional, but higher than normal stages through 1999. It therefore seems unlikely that the antecedent drought hypothesis offers much explanation for why 2000 – 2002 had such high nesting effort. So these nesting seasons offer an important perspective on the antecedent drought hypothesis – although antecedent periods of drought are apparently sufficient to produce extremely large nesting events in the Everglades, they are not the only conditions that will necessarily produce big nesting events.

During 2000 and to a lesser extent 2001, drought conditions prevailed throughout much of the southeastern U.S. This drought resulted in the drying of many marshes, streams and even lakes, leaving much of the habitat typically available to wading birds with little or no surface water. In most cases, wading bird colonies were not even initiated in these dry or drying areas. For example, by late March 2000 only one of the 11 known Wood stork colonies in Georgia had initiated nesting. In north Florida, most wading bird colonies did not initiate, and those that did were not successful. The drought in 2000 was severe enough to affect large areas of freshwater wetlands in Georgia, parts of South Carolina, north Florida and Alabama. South Florida was therefore one of the only places in the region that held water during the drought. Thus most of the wading birds in the southeastern U.S. were left with little habitat during spring 2000, and it is quite likely that the large numbers of birds in south Florida included many birds that typically nest in other states. In support of this hypothesis, Corkscrew Swamp Sanctuary also had many more storks attempt to nest than usual during 1999 and 2000; this area was also wet, but has obviously not had the same water management history as the Everglades. Although the drought conditions in 2001 were not as extensive throughout the southeast as in 2000, much of peninsular Florida remained too dry for nesting. It is also possible that there was an effect of prior experience that resulted in many birds returning to nest in the Everglades in 2001, as a result of having had excellent nesting success there in 2000. The influence of prior experience on choice of nesting location is poorly documented for wading birds.

Finally, there is the possibility that the large nesting events of 2000, 2001, and 2002, and the somewhat smaller event of 1999 were related to the decrease in mercury contamination recorded over the period 1994 – 2005 (cf 90% reduction). Over this period, a standardized measure of mercury contamination in Great Egret nestling feathers decreased by over 85%, possibly as a result of reduced atmospheric inputs of mercury from local waste-burning facilities (Frederick et al. 2001). This reduction in contamination has been quite significant in predatory fish as well, suggesting that the entire food chain has become considerably less contaminated.

Mercury has many potential sublethal effects on wading birds, including lethargy, altered immunology and blood chemistry, lower fledging weights, altered adult reproductive and parental behavior, altered chick behavior, reduced survival, and effects on hormone levels. Feather mercury levels in adult ibises are associated with elevated testosterone and depressed estrogen levels at particular stages of reproduction (Heath 2003). Although this evidence is suggestive of a causal relationship between mercury and endocrinology, this does not constitute hard evidence of mercury-related effects on reproduction. Nonetheless, experimental work with other species has indicated a causal relationship between mercury and hormone production, and it therefore seems likely that the correlative evidence we have presented is indicative of a causal relationship – high mercury contamination causes reductions in breeding or breeding success.

Although stage-specific effects have yet to be measured, it is not implausible that mercury contamination could have an effect on the ability of birds to come into reproductive condition. The interplay between day-length, body condition, and endocrinology as causative agents in the initiation of breeding is not very well worked out in many birds. However, if mercury is likely to disrupt the production or reception of hormones, and is likely to alter appetite, health and body condition, it seems quite possible that at some concentration, mercury could alter the thresholds of physiological and ecological cues used by birds to breed. Although the available evidence from the Everglades does not allow us to conclude that reductions in mercury were a contributing factor to the large nestings of the last several years, we are certainly unable to reject this hypothesis, and believe it should be retained as one of a suite of potential explanatory variables.

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Appendix 1.5. Location and composition of wading bird colonies in WCAs 2 and 3 of the Everglades during 2006.

COLONY NAME	LAT/LONG	WCA	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YC
Alley North**	N26 12.130 W80 31.750	3	1193	13566		200	22	320	214	3000	470	40	20
Hidden	N25 46.360 W80 50.240	3	300	1868									
	N26 05.999 W80 27.365	3	215				5			694			
3B Mud East	N25 48.080 W80 29.400	3	256	203	15					200			
Vulture**	N26 01.331 W80 32.213	3	378				1			80			
Big Mel	N26 02.655 W80 37.589	3	318							89			
	N26 00.738 W80 37.940	3	120				2			200			
Crossover	N25 55.510 W80 50.100	3	140		175								
6th Bridge Island	N26 07.423 W80 32.544	3	200				12						
	N25 48.344 W80 50.896	3	204										
Cypress City**	N26 07.468 W80 30.163	3	173			60	8						
	N25 57.723 W80 34.344	3		16			4				157		
Vacation **	N25 54.939 W80 37.813	3	120			45	6	10	5	35			
	N26 02.032 W80 40.442	3									138		
	N25 52.383 W80 39.208	3	114										
	N25 52.149 W80 48.359	3	8					50			55		
Yonteau	N25 49.239 W80 40.616	3	113										
	N25 51.671 W80 50.234	3	85				2						
	N26 07.934 W80 42.127	3	81										
	N26 00.963 W80 47.652	3						80	1				
Little D	N25 46.300 W80 41.590	3	80			80							
	N25 59.013 W80 48.761	3									80		
	N25 52.484 W80 39.262	3	70										
	N26 07.669 W80 43.464	3	65										
	N25 59.209 W80 41.718	3	62				2						
	N26 00.925 W80 33.811	3					2			60			
	N25 58.228 W80 41.994	3	61										
	N25 57.175 W80 39.176	3	56				4						
Henry **	N25 49.246 W80 50.469	3	55			35	1						
	N25 55.296 W80 31.158	3	56										

	N26 06.621	W80 43.433	3	52					
	N25 55.522	W80 46.730	3						49
	N26 06.990	W80 39.634	3					47	
	N25 53.308	W80 48.292	3				45		
	N26 00.816	W80 27.379	3	24	20				
	N26 02.192	W80 40.842	3						43
	N25 49.254	W80 40.619	3	40		2			
	N26 06.429	W80 29.881	3	40					
	N25 56.200	W80 44.119	3	34		5			
	N26 07.205	W80 38.337	3	34					
	N26 05.999	W80 27.365	3	32					
	N26 02.715	W80 40.350	3	7				24	
	N26 09.559	W80 34.582	3	6				25	
	N26 00.165	W80 35.646	3						30
	N26 02.966	W80 40.602	3						30
	N26 12.582	W80 39.899	3						30
	N26 02.056	W80 48.359	3				30		
	N26 06.585	W80 44.108	3	29					
	N25 57.596	W80 28.718	3	29					
Starter Mel	N25 56.803	W80 38.269	3	29					
	N25 53.313	W80 33.767	3	27		1			
	N25 46.826	W80 36.766	3	26					
	N25 48.887	W80 36.150	3	26					
	N25 50.973	W80 31.109	3	25					
	N25 48.889	W80 36.156	3	24					
	N26 00.226	W80 35.857	3	24					
	N26 01.966	W80 45.663	3	22					
	N25 50.848	W80 31.398	3	22					
	N26 06.269	W80 42.077	3						22
	N26 00.054	W80 46.729	3	21					
	N25 50.356	W80 31.802	3	21					
	N26 01.259	W80 40.898	3	10	10				
	N26 04.546	W80 37.440	3						20

N25 53.329	W80 48.215	3									20		
N26 06.935	W80 44.604	3	17				2						
N26 07.408	W80 43.313	3	19										
N26 03.001	W80 46.943	3					1	8	2		8		
N25 49.464	W80 38.550	3	17										
N25 52.742	W80 31.691	3	15										
N26 02.282	W80 28.333	3									15		
N25 50.910	W80 31.952	3	15										
N26 02.646	W80 38.887	3									15		
N26 03.271	W80 43.985	3		15									
N25 58.817	W80 39.290	3	14										
N26 05.111	W80 45.336	3							14				
N25 56.399	W80 37.324	3	13										
N25 49.424	W80 38.389	3	12										
N25 51.024	W80 40.430	3	9				3						
N25 45.823	W80 41.766	3	11										
N25 50.913	W80 31.694	3	11										
N25 50.890	W80 31.588	3	10										
N25 55.581	W80 41.124	3	9				1						
N25 58.477	W80 37.562	3	10										
N26 05.860	W80 42.000	3					2		8				
N26 05.470	W80 47.142	3						9					
N26 01.295	W80 40.905	3	1						8				
N25 59.166	W80 42.404	3					1		8				
N25 58.136	W80 39.428	3	4				4						
N25 54.896	W80 46.434	3				19	8						
N25 46.396	W80 42.770	3	2			10	6						
N25 46.578	W80 43.518	3											8
N25 54.833	W80 44.092	3	7										
N26 02.634	W80 43.341	3	5			2			2				
N25 49.054	W80 40.329	3	6										
N26 04.256	W80 40.536	3				2	6						
N25 54.994	W80 43.974	3	4				2						

N26 00.303	W80 42.815	3	2		3		1
N26 02.407	W80 42.353	3	1		5		
N25 59.981	W80 49.337	3					6
N25 53.224	W80 42.062	3	5				
N25 58.645	W80 39.465	3	5				
N25 46.260	W80 47.505	3		14	5		
N25 57.863	W80 45.179	3		13	1		4
N26 03.013	W80 45.098	3	5				
N25 47.236	W80 43.404	3			5		
N25 57.272	W80 46.374	3			5		
N26 00.133	W80 47.000	3			4		1
N25 58.968	W80 39.395	3	3		1		
N26 01.475	W80 39.233	3	4				
N25 50.483	W80 31.621	3	4				
N25 46.633	W80 41.611	3	2	15	2		
N25 55.999	W80 42.829	3		8	4		
N25 50.132	W80 41.113	3		6	4		
N26 01.832	W80 40.954	3		1	1		3
N26 02.328	W80 47.146	3				4	
N26 04.558	W80 46.953	3				4	
N25 53.704	W80 41.713	3	1		3		
N25 57.370	W80 45.153	3			4		
N26 02.007	W80 40.519	3			4		
N25 57.771	W80 45.155	3	3				
N25 54.827	W80 44.054	3	2	40	1		
N25 50.789	W80 42.205	3		16	3		
N26 03.223	W80 45.300	3		2	3		
N26 02.758	W80 41.662	3	1	1	2		
N25 52.052	W80 44.844	3		1	3		
N25 45.943	W80 43.426	3			3		
N25 46.311	W80 46.366	3			3		
N25 59.485	W80 46.486	3			3		
N25 59.536	W80 43.544	3			3		

N26 01.679	W80 42.227	3				3
N25 51.047	W80 41.595	3		7	2	
N25 46.324	W80 41.842	3		5	2	
N25 49.819	W80 45.157	3		4	2	
N25 46.124	W80 42.817	3		4	2	
N25 48.174	W80 44.576	3	1	4	1	
N25 48.894	W80 42.842	3		3	2	
N25 55.931	W80 40.532	3		3	2	
N25 57.942	W80 44.524	3		3	2	
N25 59.774	W80 46.016	3	2	2		
N25 49.022	W80 46.369	3		2	2	
N25 58.446	W80 43.473	3		2	2	
N25 49.397	W80 43.450	3		1	2	
N25 51.580	W80 42.827	3		1	2	
N25 46.622	W80 42.715	3	2			
N25 47.759	W80 44.060	3				
N25 45.973	W80 47.780	3			2	
N25 46.144	W80 44.107	3			2	
N25 46.409	W80 46.406	3			2	
N25 46.752	W80 44.113	3			2	
N25 47.161	W80 45.726	3			2	
N25 47.424	W80 48.880	3			2	
N25 47.555	W80 46.381	3			2	
N25 48.630	W80 43.298	3	1		1	
N25 51.024	W80 42.910	3			2	
N25 52.672	W80 42.321	3			2	
N25 54.304	W80 45.278	3			2	
N25 54.782	W80 46.484	3			2	
N25 54.988	W80 47.150	3			2	
N25 56.725	W80 44.553	3			2	
N25 57.979	W80 44.475	3	1		1	
N25 58.210	W80 42.086	3			2	
N26 00.724	W80 41.061	3			1	1

N26 02.369	W80 43.357	3			2			
N26 03.061	W80 40.595	3			1		1	
N26 03.163	W80 45.235	3			2			
N26 03.363	W80 47.111	3			1		1	
N25 59.135	W80 48.779	3					2	
N25 47.024	W80 43.922	3		25	1			
N25 47.903	W80 46.954	3		17	1			
N25 46.741	W80 42.137	3		15	1			
N25 48.384	W80 47.761	3		9	1			
N25 53.070	W80 45.965	3		8	1			
N25 51.976	W80 48.472	3		7	1			
N25 48.380	W80 47.171	3		6	1			
N25 53.222	W80 46.887	3		6	1			
N25 49.398	W80 43.300	3		5	1			
N25 46.675	W80 45.800	3		4	1			
N25 47.035	W80 48.395	3		4	1			
N25 49.675	W80 40.530	3		4	1			
N25 53.616	W80 40.587	3		3	1			
N25 53.630	W80 44.641	3		3	1			
N25 56.393	W80 44.717	3		3	1			
N25 56.499	W80 42.988	3		3	1			
N25 54.365	W80 47.668	3		2	1			
N25 55.788	W80 41.632	3		2	1			
N25 57.321	W80 40.426	3		2	1			
N25 58.770	W80 41.734	3		2	1			
N26 02.352	W80 47.057	3		1		1		
N25 47.001	W80 45.166	3		1	1			
N25 53.773	W80 42.847	3		1	1			
N25 55.714	W80 41.267	3		1	1			
N25 57.489	W80 46.462	3		1	1			
N26 04.558	W80 45.812	3						1
N26 03.944	W80 44.159	3	1					
N25 25.246	W80 47.121	3			1			

N25 45.979	W80 48.853	3	1
N25 46.117	W80 47.775	3	1
N25 46.195	W80 47.553	3	1
N25 46.505	W80 45.822	3	1
N25 46.646	W80 45.740	3	1
N25 46.790	W80 46.955	3	1
N25 46.957	W80 48.463	3	1
N25 47.045	W80 46.526	3	1
N25 47.196	W80 46.548	3	1
N25 47.378	W80 43.948	3	1
N25 47.533	W80 46.453	3	1
N25 47.584	W80 47.657	3	1
N25 47.661	W80 48.710	3	1
N25 47.752	W80 46.546	3	1
N25 48.086	W80 45.863	3	1
N25 48.100	W80 45.748	3	1
N25 48.275	W80 43.309	3	1
N25 48.344	W80 45.765	3	1
N25 49.393	W80 40.324	3	1
N25 50.189	W80 45.295	3	1
N25 50.216	W80 46.602	3	1
N25 50.595	W80 43.439	3	1
N25 50.976	W80 45.828	3	1
N25 51.261	W80 46.621	3	1
N25 52.079	W80 45.713	3	1
N25 52.495	W80 44.102	3	1
N25 52.626	W80 45.335	3	1
N25 52.773	W80 43.494	3	1
N25 53.243	W80 48.243	3	1
N25 53.542	W80 46.455	3	1
N25 53.755	W80 45.318	3	1
N25 54.089	W80 44.504	3	1
N25 55.098	W80 43.453	3	1

N25 55.947	W80 44.600	3		1	
N25 56.110	W80 45.899	3		1	
N25 56.268	W80 45.867	3		1	
N25 56.457	W80 45.276	3		1	
N25 57.298	W80 41.115	3		1	
N25 57.767	W80 43.530	3		1	
N25 58.103	W80 41.746	3		1	
N25 58.125	W80 44.723	3		1	
N25 58.466	W80 46.487	3		1	
N25 59.278	W80 40.312	3		1	
N26 02.465	W80 42.273	3		1	
N26 04.545	W80 43.988	3		1	
N25 59.251	W80 48.240	3			1
N26 00.012	W80 45.817	3			1
N26 00.875	W80 47.014	3			1
N26 01.615	W80 42.348	3			1
N25 46.350	W80 47.040	3		1	
N25 50.608	W80 42.259	3		1	
N25 51.954	W80 45.831	3		1	
N25 52.474	W80 48.122	3		1	
N25 52.791	W80 47.666	3		1	
N25 53.510	W80 47.610	3		1	
N25 54.341	W80 45.975	3		1	
N25 58.646	W80 42.199	3		1	
N25 51.502	W80 47.590	3	23		
N25 56.348	W80 44.755	3	16		
N25 50.586	W80 47.689	3	10		
N25 48.054	W80 48.218	3	9		
N25 46.554	W80 47.771	3	8		
N25 54.092	W80 46.417	3	8		
N25 54.877	W80 43.367	3	5		
N25 56.493	W80 40.336	3	5		
N25 47.355	W80 45.314	3	2		

	N25 47.565	W80 44.690	3				2							
	N25 49.198	W80 45.343	3				2							
	N25 52.561	W80 47.645	3				2							
	N25 54.581	W80 43.264	3				2							
	N25 55.283	W80 43.401	3				2							
	N25 56.705	W80 40.463	3				2							
	N25 47.627	W80 43.912	3				1							
	N25 51.477	W80 44.623	3				1							
	N25 51.768	W80 42.236	3				1							
	N25 51.794	W80 42.309	3				1							
	N25 52.702	W80 42.693	3				1							
	N25 54.933	W80 43.390	3				1							
	N26 14.538	W80 21.043	2	57							85			
2B Melaleuca	N26 07.780	W80 40.740	2	134										
	N26 14.944	W80 19.471	2	116										
	N26 14.990	W80 19.400	2	6								20		
	N26 16.328	W80 19.559	2									10		
Total, all colonies in WCAs 2 and 3				5,697	15,698	190	850	328	561	289	4,540	1,212	40	28

Appendix 1.6. Location and composition of colonies in Loxahatchee National Wildlife Refuge (WCA 1) in 2006.

COLONY NAME	LAT/LONG	WCA	GREG	WHIB	WOST	ANHI	GBHE	TRHE	BCNH	SNEG	LBHE	ROSP	YCNH	GLIB	COLO Y TOTA *
New Colony 3	N26 32.168 W80 17.652	1		4800					30	200				50	5,080
	N26 27.421 W80 14.441	1	437							1600					2,037
Lox 99	N26 26.208 W80 23.454	1	1136							900					2,036
	N26 23.912 W80 14.955	1	73	200						140					413
	N26 28.116 W80 22.376	1								397					397
	N26 22.330 W80 15.612	1	108	194											302
	N26 31.997 W80 16.539	1								177					177
	N26 22.460 W80 18.680	1								100					100
	N26 31.381 W80 15.983	1								81					81
	N26 22.105 W80 15.197	1						30			50				80
	N26 27.606 W80 25.379	1								60					60
	N26 33.276 W80 15.904	1					3			50					53
	N26 27.435 W80 21.351	1	33												33
	N26 33.442 W80 15.592	1								28					28
	N26 30.596 W80 19.354	1								12					12
	N26 37.406 W80 25.461	1	7												7
	N26 23.564 W80 20.341	1	6												6
total, all colonies in WCA 1			1,800	5,194	0	0	3	30	30	3,745	50	0	0	50	10,902

CHAPTER II. WADING BIRD COLONY TIMING, LOCATION, AND SIZE AT LAKE OKEECHOBEE

SOUTH FLORIDA/CARIBBEAN COOPERATIVE ECOSYSTEMS UNIT

National Park Service Cooperative Agreement with Florida Atlantic University
Task number J5297 05 0083

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Boca Raton, Florida

WADING BIRD COLONY TIMING, LOCATION, AND SIZE AT LAKE OKEECHOBEE IN 2005

Executive Summary

Wading bird nesting responses (timing, location, numbers of nests) are an important variable in evaluating the success of the Comprehensive Everglades Restoration Plan (CERP). Although records of nesting wading birds go back to the late 1800's and the coverage has been thorough in some parts of the Everglades for a decade, there are several parts of the south Florida ecosystem that have not been surveyed at all, or have not been surveyed regularly or systematically. The purpose of this CERP-funded MAP project is to expand coverage of the surveys to give a comprehensive picture of nesting in the south Florida ecosystem, including Lake Okeechobee, the Water Conservation Areas, Big Cypress National Preserve, Holey Land and Rotenberger, Everglades National Park and Florida Bay. Not all species of wading birds are considered of equal importance in monitoring the success of CERP, and the focus is now on large white species, especially Wood Storks, White Ibises, Snowy Egrets, and Roseate Spoonbills. Here, we report on nesting and nesting conditions on Lake Okeechobee during 2005.

In general, early nesting conditions in the winter/spring of 2004/5 were excellent with relatively high water levels in all pools, and rapid to very rapid drying throughout the system, November through February.

Our project expanded MAP coverage to Lake Okeechobee, which had not been surveyed since 1992. We focused specifically on populations of white waders nesting in the lake's littoral zone. Project objectives were highlighted as Task 3 in the Statement of Work associated with Florida Atlantic University's agreement with the National Park Service and directly linked to the monitoring or supporting research components identified as MAP Activity Number 3.1.3.13 and 3.1.3.14.

In May of 2005, Florida Atlantic University received funding to survey wading bird nests on Lake Okeechobee as part of the MAP of CERP. This year we were able to conduct one complete aerial survey just as the rainy season and rising lake levels began. During the morning of 3 Jun 2005, two observers surveyed wading bird nests along aerial transects flown with a Cessna 172 at an altitude of 800 ft and a speed of 100 knots. In total, we located 8 colonies with nesting wading birds. We counted 1,590 great egret, 28 tricolored heron, 9 little blue heron, and 3005 cattle egret nests. To our knowledge, our survey represents the first systematic wading bird nest survey of Lake Okeechobee since 1992. The number of colonies was within the range reported in past studies and typical of a year with high water. Because of the late project start, it is possible that some colonies had already abandoned their nests, as they had done in the central and southern Everglades.

Weather and water conditions during 2005

Temperatures

The winter and spring of 2005 were not particularly cold or hot by the standards of long term records – and were not characterized by extreme freezes (Figure 2.1). Although the data below are from a single station, this is adequate for detecting extreme temperature changes, particularly for those which occur at large geographic scales.

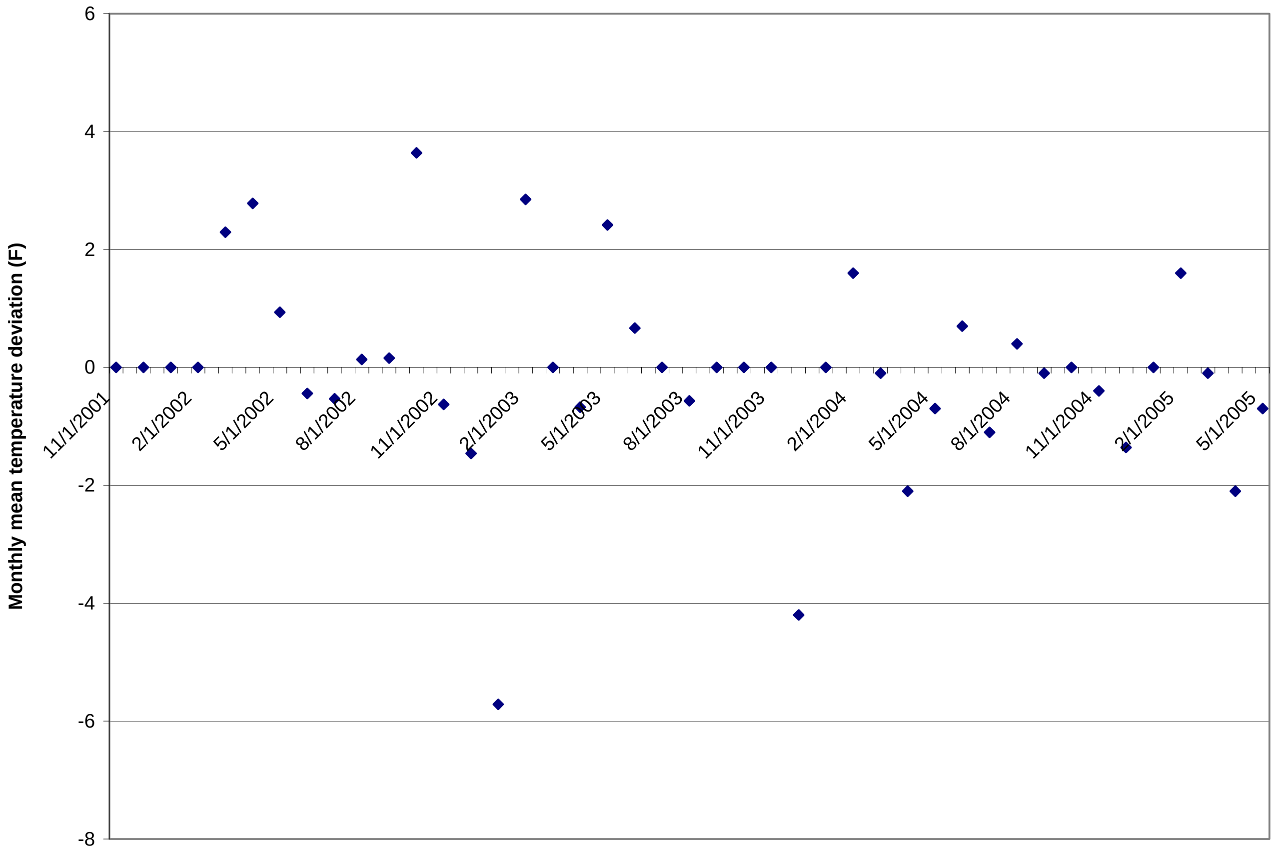


Figure 2.1. Mean monthly temperature at Tamiami Trail Ranger Station (40-mile bend), 2001 – 2005. Zero line indicates the monthly mean for the period of record, dots are the actual deviations from the mean in each month.

Rainfall

The rainy season of 2004 was characterized by very low rainfall in June, followed by large amounts of rain in August, mostly from tropical storms and hurricanes. This left the system fairly full by the time of nesting. The spring was rainier than usual (Figure 2.2) with rainfall totals in January at or close to one standard deviation in excess of the monthly mean, and well in excess of that in February. The winter/spring rainfall events were spaced closely enough that nesting cohorts that abandoned in response to one also experienced the next if they renested.

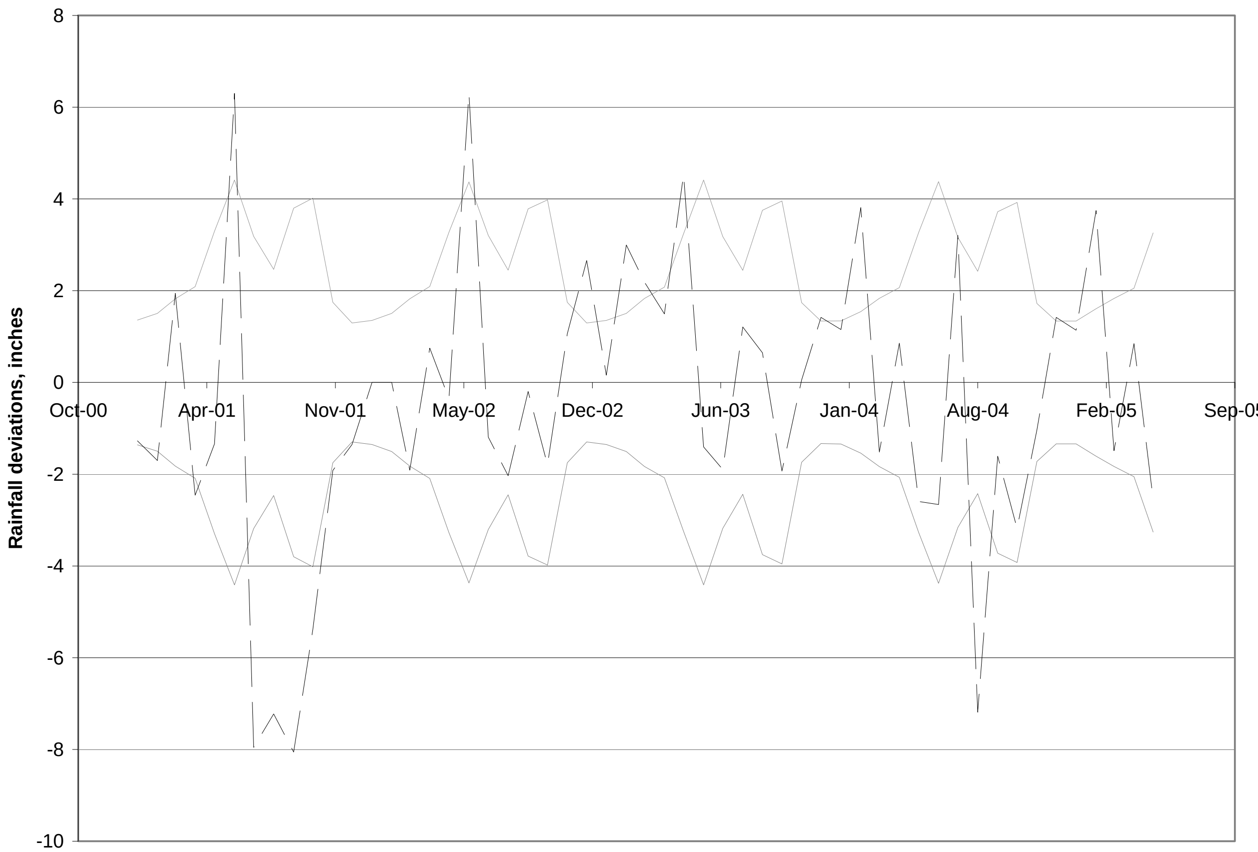


Figure 2.2. Deviations from mean monthly rainfall at Tamiami Trail Ranger Station (40-mile bend), 2000 – 2005. Zero line indicates the mean monthly rainfall, solid fluctuating lines are one standard deviation in excess or deficit of the mean deviations, and dotted line is actual deviations measured in each month.

Hydrology

In general, the 2004/5 water levels on Lake Okeechobee were normal to high, fluctuating between a high of nearly 18 feet in November 2004, and a low of about 12 feet in May 2005 (Figure 2.3). Hurricanes and tropical storms brought heavy rainfall to the area throughout the late summer and early fall of 2004, and peak levels in November were close to mean monthly maximums. After a relatively rapid decline in water levels through February, heavy rainfall in February and March resulted in a rising stage throughout March, and a strongly interrupted drying trend. Lowest stages were well within the boundaries of mean monthly lows during the period of record.

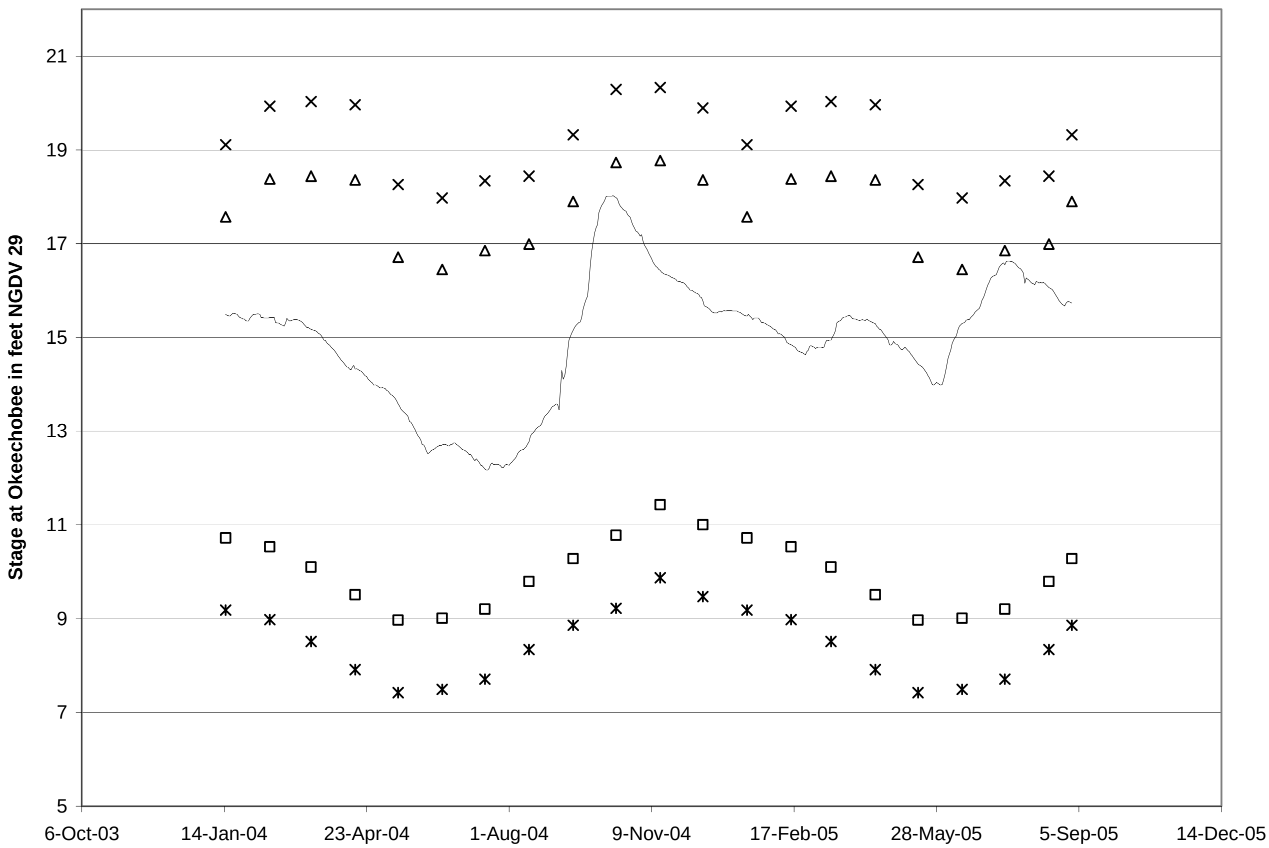


Figure 2.3. Stage at Lake Okeechobee, 2004 – 2005, showing actual stage (line), mean monthly minimum for the period of record (1931 – 2004, depicted as squares), minimums minus one standard deviation (asterisks), mean monthly maximums (triangles) and mean monthly maximums plus one standard deviation (x's). Stage in feet was recorded using the National Geodetic Vertical Datum of 1929 (FT NGVD29) from station L_OKEE (Latitude = 26 57 01.2, Longitude = 80 49 59.2). Data courtesy of the South Florida Water Management District.

Study Area

With a surface area of 1,732 km^2, Lake Okeechobee is recognized as the third largest lake in the United States (Aumen 1995). The lake is subtropical and shallow throughout with an average depth of 2.7 m. Historically, Lake Okeechobee expanded and contracted coincident with seasonal fluctuations in precipitation and evapotranspiration. Today, however, the lake is completely surrounded by a levee and its ebb and flow are managed by 32 water control structures (Aumen 1995). The United States Army Corps of Engineers and the South Florida Water Management District (SFWMD) share primary responsibility for managing Okeechobee's water levels. The SFWMD and Florida Department of Environmental Protection share responsibility for monitoring water quality.

Lake Okeechobee has a littoral zone that covers almost 25%, or approximately 400 km^2 of its surface area. The littoral zone functions as a large freshwater marsh that contains a diverse community of emergent, floating, and submerged aquatic vegetation and serves as an important nesting and foraging area for wading birds during their breeding cycle.

Methods

On the morning of 3 Jun 2005, two observers surveyed wading bird nests along aerial transects flown with a Cessna 172 at an altitude of 800 ft and a speed of 100 knots. Transects were oriented E-W and spaced at an interval of 1.6 nautical miles. One observer was placed on either side of the plane. Once a colony was located, the altitude was reduced to 300 feet and the colony was circled until a nest count was completed. While circling, one observer counted while the other recorded the data. We report numbers only for numbers of active nests (i.e., with adult or chick in or adjacent to nest). In many cases, large numbers of birds were perched in the colony but not on nests. Glossy Ibises were seen in the Chancy Bay colony but were not on nests. Although the monitoring protocol calls for ground counts in addition to aerial surveys, we did not have enough time to conduct a ground count before the start of the wet season and therefore we probably missed many dark-colored wading birds. We report the lack of dark-colored birds as a missing value rather than as a 0, in contrast to the light birds for which we feel confident we saw when they were present.

Results

We located 8 colonies with nesting wading birds in the littoral zone of Lake Okeechobee in 2005 (Fig. 4.1). One colony with only Anhingas was discovered but not reported. Our surveys showed that nesting this year was dominated overwhelmingly by the Cattle Egret, which was found in 7 of 8 colonies for a total of 3,005 nests, and the Great Egret, which also was found in 7 of 8 colonies for a total of 1,590 nests (Table 2.1). The Rock Island and Clewiston Spit colonies were on spoil islands whereas all others were on willow heads (Figure 2.2). While the species composition and numbers of birds nesting were similar to previous years on Okeechobee, it should be remembered that our surveys this year did not begin until May due to the timing of the receipt of funding. Given the large weather-related abandonments in the rest of the system in March, it would not have been surprising if there were many more nests initiated earlier in the season that we missed with our late survey. For this reason, the Lake Okeechobee counts can probably be considered a fairly conservative estimate of the true numbers of nests.

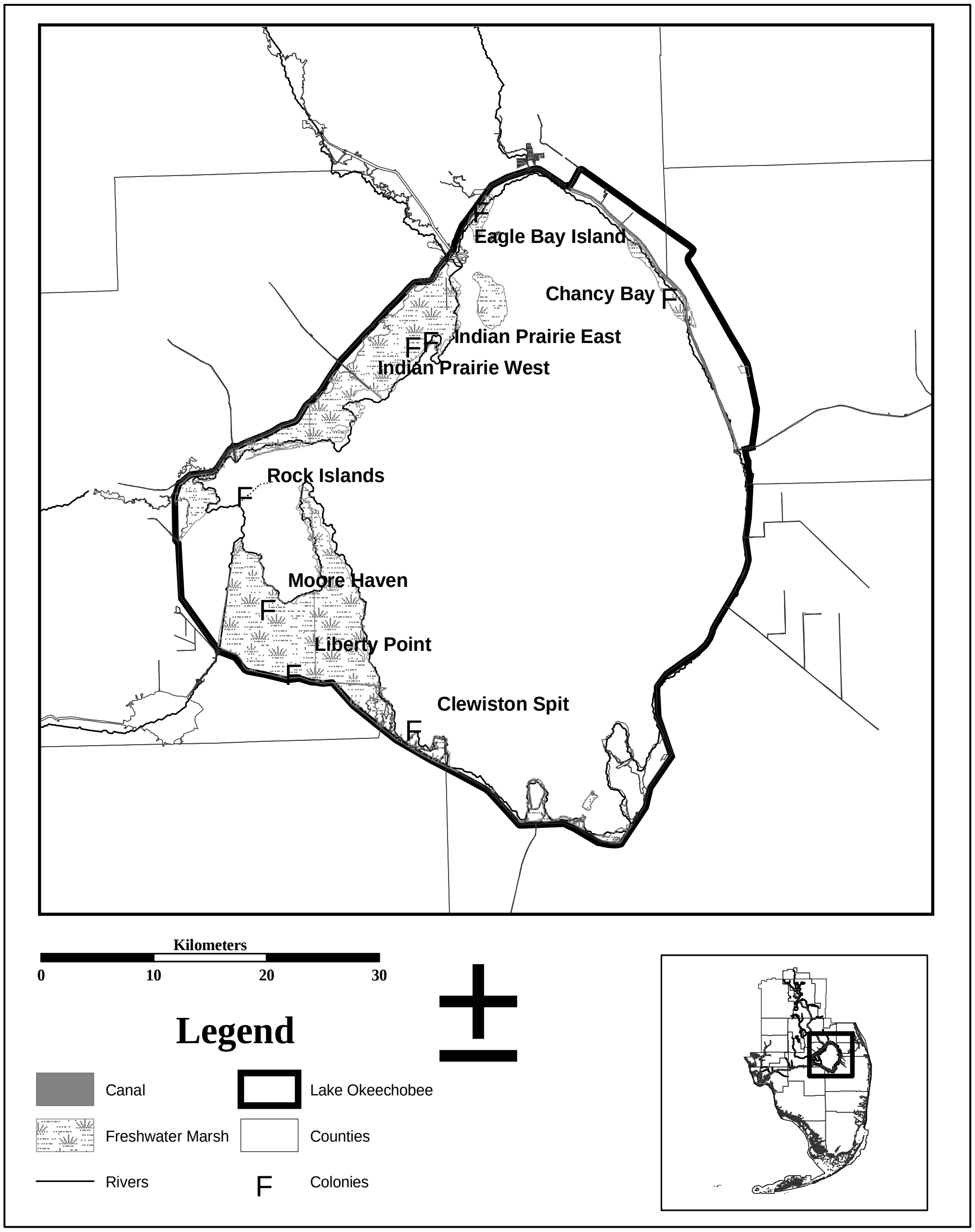


Figure 2.4. Wading bird colonies at Lake Okeechobee, Florida, June 3, 2005 (NAD83).

Table 4.1. Locations (decimal degrees, NAD83) and numbers of wading bird nests among wading bird colonies found at Lake Okeechobee, Florida, June 3, 2005.

Colony Name	**Latitude**	**Longitude**	**Great egret**	**Tricolored heron**	**Little blue heron**	**Cattle egret**	**Colony totals** [1]
Clewiston Spit	26.777767N	80.908533W	30	---[2]	---	20	**30**
Liberty Point	26.823550N	81.014717W	85	5	---	20	**90**
Moore Haven	26.874317N	81.036350W	600	15	8	25	**623**
Rock Islands	26.962617N	81.054300W	655	2	---	300	**657**
Indian Prairie West	27.075633N	80.901083W	20	6	1	0	**27**
Indian Prairie East	27.079500N	80.885133W	90	---	---	740	**90**
Eagle Bay Island	27.179183N	80.837133W	110	---	---	1200	**110**
Chancy Bay	27.108117N	80.670867W	0	---	---	700	**0**
Total nests			**1590**	**28**	**9**	**3005**	**1627**

[1] Colony totals excluded Cattle Egrets
[2] Species not detected

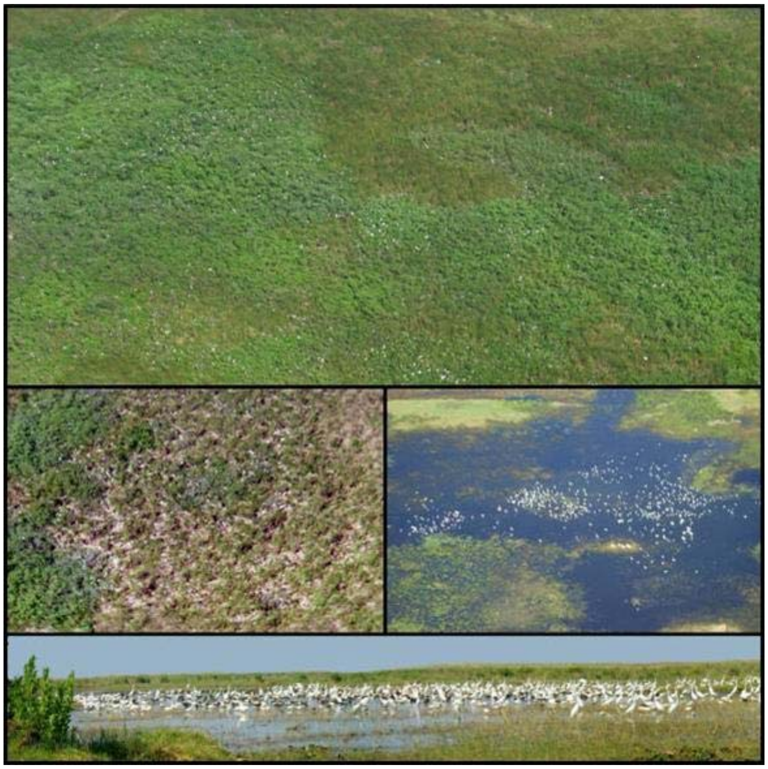
Figure 2.5. Photos of four colonies. From upper left to lower right: Moore Haven, Eagle Bay Island, Rock Islands, and Indian Prairie.

Discussion

Colony counts of nesting wading birds in Lake Okeechobee were reported by National Audubon Society wardens sporadically during the 1930 and 1940s. The first systematic aerial survey of the lake was conducted in 1957 (David 1994). Thereafter surveys were done sporadically until 1977. From 1977 to 1992, aerial surveys were conducted annually (David 1994, Smith and Collopy 1995). To our knowledge, our survey represents the first systematic wading bird nest survey of Lake Okeechobee since 1992.
The number of colonies on Lake Okeechobee this year was within the range reported by Smith and Collopy (1995) and was typical of a year with high water. Our surveys showed that nesting this year was dominated overwhelmingly by the Cattle Egret and Great Egret. The former species feeds primarily outside the lake boundaries, and the latter species can feed in deeper water than the smaller wading birds. The number of Great Egrets was above the historic average (David 1994). However, the number of nests of other species and the overall number of nesting wading birds (Cattle Egrets excluded) was below average. Because of the late project start date, it is possible that some colonies had already abandoned

their nests, as they had done in the Everglades, and our estimates should be treated as conservatively biased.

WADING BIRD COLONY TIMING, LOCATION, AND SIZE AT LAKE OKEECHOBEE IN 2006



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Introduction

The importance of Lake Okeechobee to South Florida wading bird populations has been recognized since National Audubon Society wardens began patrolling the area during the early 20th century (David 1994a). The earliest systematic aerial surveys were conducted at Okeechobee from 1957 to 1960, and then again during the early 1970s, as part of regional and statewide efforts to monitor wading birds (David 1994a). Nest counts for Great Blue Herons, Great Egrets, Snowy Egrets, White Ibis, and Glossy Ibis reached a high point of 10,400 in 1974 (Ogden 1974, David 1994a). In response to concerns about the effect of proposed management increases in lake levels on wading birds, the South Florida Water Management District (SFWMD) began in 1977, monthly surveys of nesting birds throughout the breeding season that ran annually until 1992 (David 1994a, Smith and Collopy 1995). During this period, the overall presence of breeding wading birds on Lake Okeechobee declined by 60%, with Glossy and White Ibises declining by 83% and 74%, respectively (David 1994a). There were no other surveys on the Lake until 2005, when Florida Atlantic University (FAU) conducted a single survey at the end of the nesting season. Then in 2006, FAU initiated monthly aerial surveys to determine the size and location of wading bird colonies on Lake Okeechobee as part of the Monitoring and Assessment Plan of the Comprehensive Everglades Restoration Plan. Herein, we report the results of the 2006 surveys, discuss their historical significance, and then attempt to link our findings to regional hydrologic conditions.

Methods

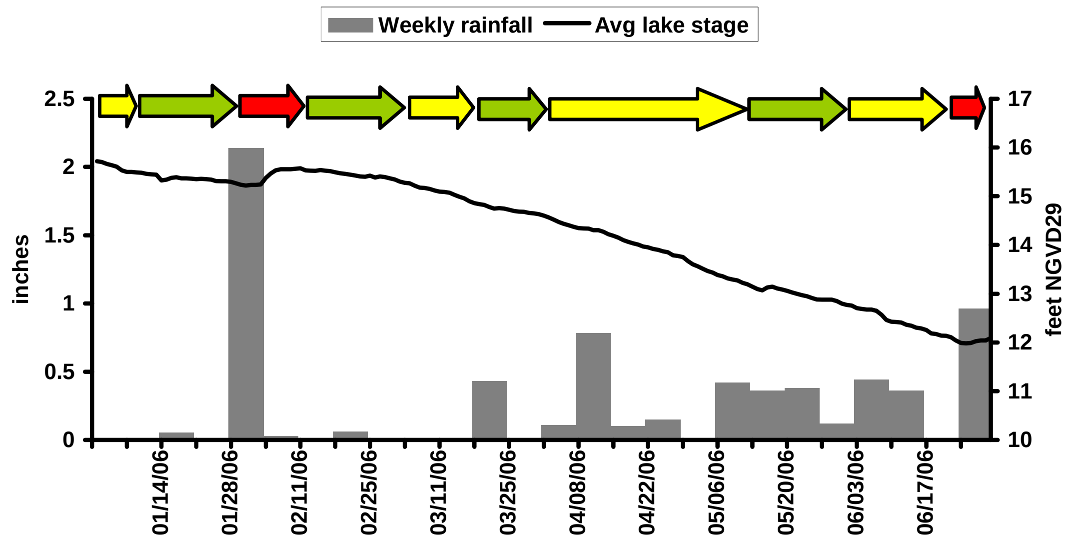
Aerial Surveys

From January through June 2006, two observers surveyed wading bird nests along aerial transects flown in a Cessna 172 at an altitude of 244 m (800 ft) and a speed of 185 km/hr (100 knots). One transect was flown parallel to the eastern rim of the lake from Eagle Bay to Ritta Islands. Remaining transects were oriented East-West, spaced at an interval of 3 km (1.6 nm), and traversed the littoral zone. Observers searched for colonies on each side of the plane. Colonies were defined as any assemblage of at least 2 nests separated by at least 200 m (Erwin et al. 1981, Smith and Collopy 1995). When a colony was located, we lowered to 91 m (300 ft), and the colony was circled several times until a nest count was completed. One observer counted while the other recorded data. We also recorded photographs and geographic coordinates with each visit and then mapped colonies to specific stands of vegetation or islands onto 1-m resolution digital orthophotoquarterquadrangles (DOQQs). We calculated intercolony distances using ArcGIS. To maintain consistency with past wading bird reports for Lake Okeechobee, we counted all birds sighted and categorized them as "nesting" if nests were visible or known assemblages of nests existed for a species (David 1994a, Smith and Collopy 1995). At the largest, most diverse, and accessible colonies, we followed aerial surveys with ground surveys to improve count accuracy (Frederick et al. 1996). Even with combined ground surveys and photographs, however, small dark-colored wading birds were difficult to census, and therefore we likely underrepresented the presence of dark-colored wading birds in our counts. We also compared 2006 colony locations to published maps of past wading bird colony survey results (David 1994a, Smith and Collopy 1995) to determine whether a site was a new colony or had historical significance.

Hydrology

Lake stages and recession rates reported herein were based on average stage readings from six principal gauges at Lake Okeechobee. Four are located in the pelagic zone throughout the lake (L001, L002, LAKEOKEE, LZ40), one near Moonshine Bay (L005), and one in the littoral zone near Liberty Point (L_OKEE.M_G). Lake stage receded steadily throughout the breeding season following a brief reversal due to heavy rains early in February (Figure 2.6). All water levels and lake stages are reported as feet National Geodetic Vertical Datum 1927 (NGVD29). Foraging surveys suggested that as the average lake stage dropped below 15 ft in March, water depths in the marsh became shallow enough that large aggregations of wading birds (including small Ardeids and ibis) were beginning to forage on the lake (unpublished data). We used the recession rate index from Sklar (2005) to assess the suitability of wading bird foraging conditions. The index was based on weekly changes in lake stage once water levels in the marsh became shallow enough for wading birds to forage successfully. Data suggested that recession rates were good to fair for more than three months from March 11 until June 30 when lake levels began to increase again following initiation of the rainy season (Fig. 2.6).

Figure 1. Weekly precipitation totals (in) and average stage levels (feet NGVD29) for Lake Okeechobee, FL, USA during the 2006 wading bird breeding season. Suitability of wading bird foraging recession rates were depicted in colored arrows. Good foraging conditions (green) existed when average lake stage decreased between 0.05 ft and 0.16 ft per week, fair foraging conditions (yellow) when stage decreased between 0.17 ft and 0.6 ft or decreased only 0.04 ft per week, and poor foraging conditions (red) when stage levels increased or if decreases were >0.6 ft.



<u>Results and Discussion</u>

Historical significance and colony size

In contrast to historical nesting reports, we did not observe any activity at either King's Bar, Okeetantie, Harney Pond/Twin Palms, or Observation Island. Moreover, we observed no breeding activity at either Lake Hicpochee or in Cowpen Marsh, two former colony sites outside of the lake levee. Whether these historical sites will be reoccupied in response to shifting hydrological conditions as environmental circumstances change or as lake management strategies evolve remains to be seen. Even so, several perennial sites were occupied in 2006, and data suggested that wading birds at Lake Okeechobee initiated a substantial number of nests this year in comparison to past reports. The five most prominent colonies during 2006 were Moore Haven West 1 (A19), Moore Haven East 4 (A21), Indian

Prairie South 1 (A32), Eagle Bay Island (A1), and Liberty Point (A14), respectively (Table 2.2). These five colonies accounted for 83% of the overall peak nest effort.

Colony A19 was a traditional colony site whose location was similar to colonies reported as “Moore Haven A” by David (1994) and “North Moore Haven” by Smith and Collopy (1995). Colony A19 was this year’s largest colony, harboring 40% of the total nests with all principal wading bird species breeding there at some point during the season. At colony A21, we recorded 2,440 nests in May, 50% of which were White Ibises and 37% of which were Snowy Egrets. No previous record existed for the Indian Prairie South colonies, suggesting that breeding birds moved to new sites northeast of the traditional Harney Pond and Twin Palms sites (David 1994a, Smith and Collopy 1995). Colony A14 near Liberty Point was likely the oldest and most perennial site of all the active colonies located during 2006. Nests attempts were initiated here during 80% of the breeding seasons from 1977–1992. Colony A1 at Eagle Bay Island is not mentioned by David (1994), but was active during Smith and Collopy’s (1995) surveys, suggesting that birds that traditionally nested at King’s Bar eventually relocated to Eagle Bay Island as the King’s Bar colony gradually disbanded during the modern era. Colony A1 and Colony A14 were used by multiple species throughout the entire breeding season with May peaks of 1 525 and 1,157 nests, respectively.

Timing and peak nest effort

Large Ardeids began nesting in early December 2005 before surveys began, and small Ardeids began nesting during the third week of March. Ibises began nesting the first week of April. Several colonies remained active until the last week of June when the last surveys were conducted. We observed 11,310 wading bird nests spread across 27 colonies (Figure 2.7). This total summed the peak nest effort for each species within the 2006 breeding season, but excluded Cattle Egrets and Anhingas. We expect this was the most accurate estimate of total nest effort for the year because different species exhibited peak nest effort during different periods of the nesting season (Table 2.2). However, to put this number in its proper historical context, we also summed a separate

Table 1. Geographic coordinates (NAD83) and species-specific peak nest effort for colonies during the 2006 breeding season at Lake Okeechobee, Florida, USA.

Colony name	ID	Geographic Location		Peak nesting month	ANHI	GREG	SNEG	TRHE	LBHE	GBHE	CAEG	WHIB	GLIB	Peak nest effort [1]
		Latitude	Longitude											
Chancy Bay [3]	A29	80° 39' 58"W	27° 06' 14"N	MAY 2006	5	0	0	0	2	3	220	0	0	230
Clewiston [4]	A12	80° 53' 29"W	26° 45' 48"N	FEB 2006	0	0	0	0	0	5	0	0	0	5
Clewiston Spit [4]	A13	80° 54' 33"W	26° 46' 33"N	APR 2006	0	220	0	1	0	2	0	0	0	223
Eagle Bay Island North	A1	80° 50' 11"W	27° 11' 04"N	MAY 2006	20	55	180	40	20	0	480	480	250	1,525
Eagle Bay Island South	A2	80° 50' 47"W	27° 10' 14"N	MAR 2006	6	80	0	0	0	12	0	0	0	98
Indian Prairie North 1 [3]	A5	80° 53' 53"W	27° 05' 11"N	FEB 2006	0	0	0	0	0	6	0	0	0	6
Indian Prairie North 2 [4]	A18	80° 53' 10"W	27° 05' 05"N	MAR 2006	30	95	0	0	0	1	0	0	0	126
Indian Prairie North 3 [4]	A30	80° 53' 04"W	27° 04' 55"N	MAR 2006	23	68	0	0	0	3	0	0	0	94
Indian Prairie South 1	A32	80° 57' 47"W	27° 01' 53"N	APR 2006	0	160	800	80	80	2	480	0	0	1,602
Indian Prairie South 2	A35	80° 58' 06"W	27° 01' 33"N	MAR 2006	0	37	0	0	0	4	0	0	0	41
Torrey Island	A6	80° 45' 58"W	26° 41' 51"N	FEB 2006	0	0	0	0	0	7	0	0	0	7
Ritta Island [4]	A7	80° 48' 02"W	26° 43' 10"N	FEB 2006	0	2	0	0	0	8	0	0	0	10
Liberty Point [3]	A14	81° 00' 38"W	26° 49' 32"N	MAY 2006	83	260	550	2	12	0	0	150	100	1,157
Moore Haven East 1 [3]	A3	81° 00' 25"W	26° 51' 44"N	APR 2006	22	170	0	0	0	4	0	0	0	196
Moore Haven East 2 [3]	A4	81° 00' 39"W	26° 51' 55"N	MAR 2006	8	0	0	0	0	3	0	0	0	11
Moore Haven East 3 [3]	A20	81° 03' 08"W	26° 53' 02"N	APR 2006	70	300	200	2	20	0	0	150	5	747
Moore Haven East 4 [3]	A21	81° 02' 10"W	26° 52' 43"N	MAY 2006	0	100	900	30	60	0	0	1,200	150	2,440
Moore Haven East 5 [3]	A27	81° 01' 06"W	26° 52' 17"N	MAR 2006	15	46	0	0	0	2	0	0	0	63
Moore Haven West 1 [3]	A19	81° 05' 18"W	26° 53' 53"N	APR 2006	60	300	850	30	18	4	20	5,000	40	6,325
Moore Haven West 2 [3]	A28	81° 05' 42"W	26° 53' 06"N	MAR 2006	0	90	0	0	0	1	0	0	0	91
Rock Islands 1 [3]	A15	81° 03' 04"W	26° 57' 48"N	APR 2006	8	70	130	2	1	1	50	0	0	262
Rock Islands 2 [3]	A33	81° 02' 48"W	26° 58' 01"N	APR 2006	6	30	90	16	0	0	20	0	0	162
Rock Islands 3 [3]	A38	81° 02' 57"W	26° 57' 54"N	APR 2006	0	0	0	0	0	0	35	0	0	45
Rock Islands 4 [3]	A40	81° 02' 12"W	26° 58' 20"N	MAY 2006	0	0	0	0	0	0	140	0	0	140
South Bay 1	A23	80° 43' 30"W	26° 41' 37"N	MAR 2006	0	0	0	0	0	2	0	0	0	2
South Bay 2	A24	80° 44' 05"W	26° 41' 23"N	MAY 2006	0	26	0	0	1	1	0	0	0	28
South Bay 3	A39	80° 43' 41"W	26° 42' 33"N	MAY 2006	0	8	0	0	0	0	40	0	0	48

[1] Peak nest effort included all species present

[2] Species listed in descending rank order based on nest abundance at time of peak nesting

[3] Reported in David 1994 and Smith and Collopy 1995

[4] Reported in Smith and Collopy 1995

Figure 2. Map of wading bird colonies observed at Lake Okeechobee, Florida, USA, from January to June 2006.

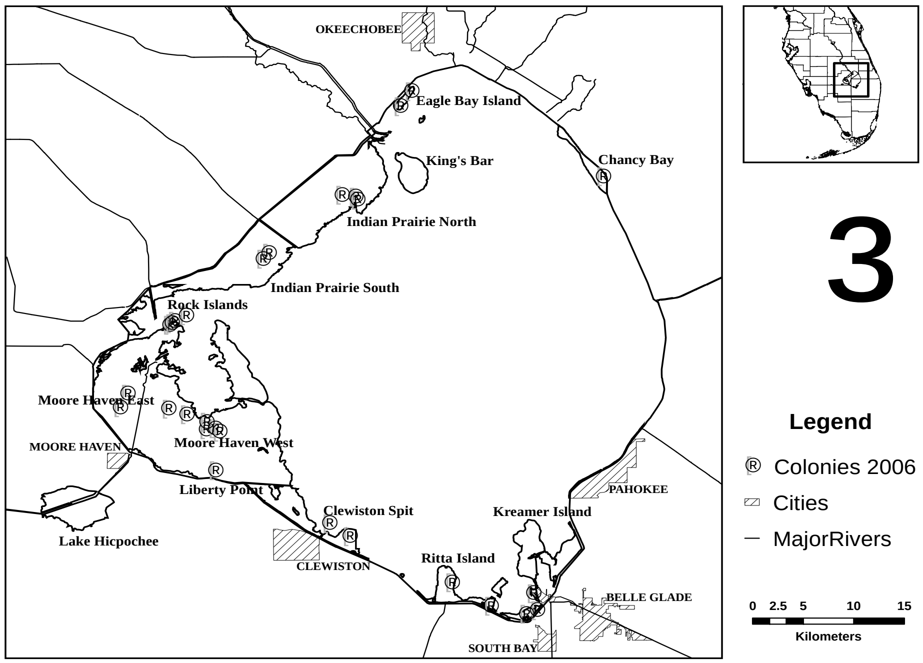


Table 2. Timing and nest effort for species breeding in wading bird colonies during 2006 at Lake Okeechobee, Florida, USA .

Date	ANHI	GREG	SNEG	TRHE	LBHE	GBHE	CAEG	GLIB	WHIB	Totals [1]
January	---	50	---	---	---	34	---	---	--- [2]	84
February	105	480	---	---	---	98	---	---	---	578
March	471	1,796	203	63	25	72	---	80	400	2,639
April	243	1,782	2,393	234	182	55	650	435	5,800	10,881
May	200	1,067	2,580	137	158	22	1,530	620	2,980	7,564
June	59	655	1,764	83	82	15	1,215	305	170	3,074

[1] Monthly totals excluded Cattle Egrets and Anhingas

[2] Species undetected during the survey

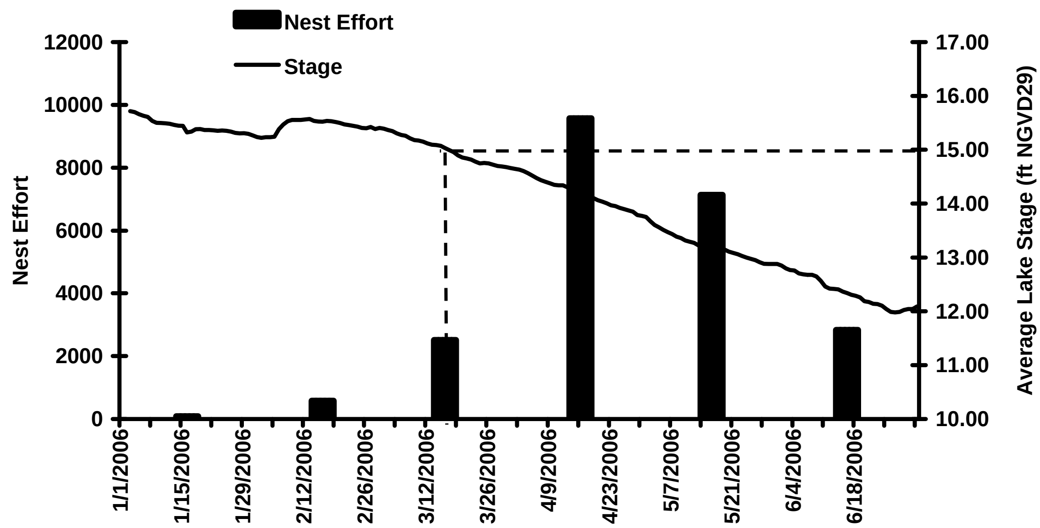
nest effort for only White Ibises, Glossy Ibises, Great Blue Herons, Great Egrets, and Snowy Egrets, which were the five species totaled in the historical nest count summary provided by David (1994). That partial count was 10,868 nests in 2006. This number of nests makes 2006 the largest nesting year since 1974. However, the early surveys (1957–1975) were sporadic between years and typically occurred only once during the breeding season, making it possible that peak nest effort was underestimated and some good years were missed.

Environmental conditions

January's high water levels in the marsh likely reduced on-lake habitat and prey availability for foraging wading birds during the early part of the breeding season. Yet Eagle Bay Island had active colonies during the first aerial survey in January. Furthermore, many of those early nests already had chicks by February 8, at the time of our first monitoring visits, suggesting that courtship and nest construction at Eagle Bay Island began in December when lake levels were still relatively high from Hurricane Wilma in October 2005. If habitat and prey availability are critical factors influencing the initiation of nesting in wading birds (Powell 1983, 1987; Strong et al. 1997, Gawlik 2002) and if availability was reduced on-lake, then we presume an above average rainy season may have increased the availability of foraging habitats off-lake in the surrounding landscape proximal to Eagle Bay Island. Indeed, short-hydroperiod wetlands in the surrounding landscape provide primary foraging habitats for wading birds while lake levels are high (Marx and Gawlik, unpub. data). Thus, we anticipate that the protection and management of these wetlands will be an important complementary component of conservation efforts to restore and sustain wading bird populations that breed on the lake.

Despite the early nests that could be tied to off-lake habitat availability, this year's nesting data also gave some guidance for the hydrologic conditions within Lake Okeechobee that might increase wading bird nesting. We expect the circumstances that produced this year's superior nest effort were related to water management that reduced average lake stage, followed by a steady recession. As managers reduced the lake stage enough to sufficiently lower water levels in the littoral zone, data suggests that marsh habitats became increasingly suitable for successful foraging which stimulated breeding (Powell 1983, 1987, Gawlik 2002). David (1994b) and Zaffke (1984) documented heightened use of the lake by foraging wading birds once average lake stage dropped below the 15-ft threshold. In 2006, once the average lake stage fell below 15 ft, there was a marked increase in wading bird nesting over the next few weeks, especially among smaller Ardeids and ibises that require shallow waters to maximize their foraging potential (Gawlik 2002; Table 2.2, Fig. 2.8). Thereafter, a steady protracted recession with no major reversals in the receding water pattern provided good to fair foraging conditions for several months during the breeding season, which allowed wading birds to complete their nest cycle. Despite the wide variety of environmental stressors that threaten Lake Okeechobee's ecological integrity (Havens and Gawlik 2005), the 2006 season demonstrated that the lake still serves as an important breeding area for South Florida wading birds (David 1994a).

Figure 3. Wading bird nest effort (number of nests) combined with average lake stage across the 2006 nesting season at Lake Okeechobee, FL, USA.



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CHAPTER III. ROSEATE SPOONBILL NESTING IN FLORIDA BAY: 2003-2004, 2004-2005, AND 2005-2006

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Executive Summary

With the exception of the 1993-94 nesting cycle, Audubon staff have monitored nesting success and nesting effort of Roseate Spoonbills in Florida Bay since 1984-85. In 2002, we initiated a program of banding nestling spoonbills in Florida and Tampa bays to track survivorship from their natal colony, and to assess the demographics of this important indicator species. This report addresses the continuing study to monitor nesting effort and nesting success in Florida Bay from 2003 through 2006, as well as a discussion of the results of the banding program for the same years.

During the 2003-2004 nesting season, Roseate Spoonbills nest numbers were at their lowest since 1969-70 in Florida Bay, indicating a continued downward spiral that began with completion of major water management structures in the early 1980's. Historically, the Northeastern sub-region was the most productive sub-region of the bay (Lorenz et al. 2002). Since 1982, this sub-region has been heavily impacted by major water control structures that lie immediately upstream from the foraging grounds (Lorenz 2000). The foraging grounds associated with the Northwestern sub-region were of relatively moderate quality while those in the Northeastern and Southeastern sub-regions were of poor quality. Nest production rates in these sub-regions reflect these conditions with Sandy Key in the northwest experiencing moderate success and focal colonies in the northeast and central regions essentially experiencing a total failure. It is possible that the birds from the Central sub-region were flying the relatively long distances to. Northwest foraging grounds on Cape Sable, however, the extra travel time and energetic costs of the longer foraging flights, coupled with foraging in marginal quality habitat, may have manifested itself in zero nesting success (Table 3.2).

Our hydrologic data indicates that major rainfall events occurred in late September and late October of 2003. The result was major reversals in the drying patterns on the spoonbills primary foraging grounds (i.e. water levels began to decline before the events, but rapidly increased following the rain thereby resetting the drying patterns). In Dec, another rainfall event resulted in a significant reversal, although neither the rain nor the reversal were as severe as the September and October events. We believe that these reversals disrupted the cue for nesting (which is generally believed to be tied to water levels) thereby resulting in asynchronous and delayed nesting. We also believe that the long delay in nesting and the uncertainty of the cue caused the lower than usual nesting effort. Our hydrologic data from both the eastern and western foraging grounds suggest that this was a regional phenomenon. Furthermore, the timing and

asynchronous nature of the spoonbill nesting efforts occurred in both the northeastern and northwestern bay. The observations indicate that this was a naturally occurring event and not a result of water management practices.

The spoonbill nest productivity in the northeastern bay was an order of magnitude lower than that of the northwestern bay. Since the eastern bay foraging grounds are directly affected by water management, and those in the west are only indirectly affected, these results suggest a possible negative impact of water management on spoonbills. Fifty-eight percent of the nests on Tern Key were abandoned between Jan 15 and Feb 3. In contrast, over the approximately same time period (Jan 16-Feb 5) Sandy Key only had 19% of its nests fail. We suspect that water management activities between Jan 15 and Feb 3 exacerbated an already bad situation for spoonbills nesting on Tern Key.

An examination of the rainfall data indicated that a small rainfall event (on the order of 1.25 cm) occurred on Jan 18 and 19. Although only a small amount of rain fell, the storm itself was spatially very large, covering a regional scale. Water levels at spoonbill foraging sites not affected by water management (e.g. western sites) increased 7cm. This represents the background impact of the rain due to run-off from upstream locations. Foraging sites affected by water management increased 15.5cm in the eastern bay. We attribute the difference in these water level increases to water management practices that divert unnaturally high amounts of water onto the foraging grounds. Furthermore, water levels on the impacted sites exceeded the point at which fish concentrated from Jan 18 to Jan 27. Although, no fish samples were collected during this period past analyses strongly suggest that this reversal resulted in the dispersal of prey and the high rate of nesting failure during this period.

> Observations that the nesting effort failed in the Northeastern sub-region in 2003-2004, while moderately successful in the Northwestern sub-region, indicate that up-stream operations continue to damage the Florida Bay ecosystem. Overall, the 2003-04 nesting was generally poor for natural reasons, however, water management practices exacerbated the problems in the eastern bay resulting in an abysmal production rate compared to the western bay. These data suggest that Florida Bay will continue to decline in ecologic health unless major changes are made to water management practices that effect the region.

In 2003-2004, 162 chicks were banded from 85 nests across florida bay. Of these, 27% were presumed dead before leaving the nest and 20% were observed post fledging. Outside of their natal colonies, there were no resightings of these birds nor any of the 30 birds banded in florida bay last year. In the 2004-2005 nesting season, roseate spoonbills nest numbers were below average, indicating a continued downward spiral that began with completion of major water management structures in the early 1980's, as in the 2003-2004 season.

The foraging grounds associated with the Northwestern sub-region were of relatively high quality while those in the Northeastern and Southeastern sub-regions were of poor quality. Nest production rates in these sub-regions reflect these conditions with Sandy Key in the northwest experiencing nest success and focal colonies in the northeast and central regions essentially experiencing a total failure. Again, as in the 2003-2004 season, it is possible that the birds from the Central sub-region were flying to the Northwest foraging grounds on Cape Sable, but the extra travel time and energetic costs of these flights, along with foraging in marginal quality habitat, may have resulted in low nesting success (Table 3.2).

Our observations that the nesting effort failed in the Northeastern sub-region in 2004-2005, while successful in the Northwestern sub-region, continue to indicate that upstream operations are damaging the Florida Bay ecosystem. Overall, the 2004-05 nesting was generally poor compared to average nest success over the years, however, water management practices exacerbated the problems in the eastern bay resulting in an abysmal production rate compared to the western bay. These data suggest that Florida Bay will continue to decline in ecologic health unless major changes are made to water management practices that affect the region.

In 2004-2005, 415 chicks were banded from 186 nests across Florida Bay. Of these, 11% were observed dead either before leaving the nest or outside the colony and 45% were observed alive post-fledging. Outside of their natal colonies, there was one resighting of a bird banded at Sandy Key in December observed at Shark Valley, Everglades National Park, in February. Two fledglings arrived at two wildlife rehabilitation centers in the Florida Keys, but both later died.

During the 2005-2006 nesting season, Roseate Spoonbills nest numbers were below average, just as the previous two nesting seasons were. This year, the success rate at Tern Key was the highest it has been in 14 years and well above the 0.79 c/n average since 1982. The success of nesting attempts in the Northwestern region indicated that conditions should have been good for spoonbills nesting in the Northeastern region in the absence of adverse water management practices. The coordination between ecologists and water managers may have been beneficial through avoiding adverse management practices. Regardless, conditions were excellent on the Northeastern foraging grounds and the lack of adverse management practices resulted in a highly successful nesting in that region. Repeating such cooperation between ecologists and managers in the upcoming years will reveal how successful such communications are in providing the appropriate conditions for all fauna that utilize this wetland during the draw down process.

Based on a flight-line count and fixed-wing aircraft observations, it appeared that the birds from the Central region were flying over the Russell and Black Betsy Keys to the Taylor Slough area, where they were met with quality foraging habitat. This would support their exceptional nest success (Table 3.2).

In 2005-2006, 472 chicks were banded from 187 nests across Florida Bay. Of these, 13% were observed dead either before leaving the nest or outside the colony and 44% were observed alive post-fledging. Outside of their natal colonies, there has been one resighting of a bird banded at Sandy Key in December observed foraging at Lake Ingraham, Everglades National Park, in March.

Methods

Spoonbill Colony Surveys. Thirty-five of Florida Bay's keys have been used by Roseate Spoonbills as nesting colonies (Figure 3.1, Table 3.1). These colonies have been divided into five distinct nesting regions (Table 3.1) based on each colony's primary foraging location (Figure 3.1, Lorenz et al. 2002). During the 2003-2004, 2004-2005, and 2005-2006 nesting cycle (Nov-May), complete nest counts were performed in all five regions by entering the active colony and thoroughly searching for nests. Nesting success was estimated for the four active regions through mark and re-visit surveys of the most active colony within the region. These surveys entail marking between 15 and 50 nests shortly after full clutches had been laid and re-visiting the nests on an approximate 10d cycle to monitor chick development. Prey fish availability was estimated at six sites (TR, EC and WJ in the Taylor Slough Basin and JB, SB and HC in the C-111 Basin) in the coastal wetlands of northeastern Florida Bay (Figure 3.1) known to be spoonbill foraging locations for the Northeastern and Central regions. Prey abundance was also estimated at a site located in southern Bear Lake (BL) on Cape Sable where large numbers of spoonbills nesting in the Northwestern region regularly feed. Prey fish were collected monthly from Nov through Apr with a 9m^2 drop trap using the techniques of Lorenz et al. 1997. Prey availability data have not been fully analyzed and the qualitative information presented should be considered preliminary.

Banding Program. The purpose of this banding program is to better understand the movements and dynamics of the state's spoonbill population. We are interested in where the post-breeding dispersers go, and if there is an exchange of breeders between Florida Bay and Tampa Bay, as well as state-wide and regional movements. We are hoping to see trends in spoonbills' movements with future banding and resighting efforts. Please refer anyone with information on resighting banded spoonbills to the author or our website (http://www.audubonofflorida.org/science/spoonbills.htm).

In Florida Bay, spoonbill nestlings have been banded at 22 out of the 26 colonies at which spoonbills have nested in the past three years. In Tampa Bay, we have banded spoonbills at the largest colony in the region, Alafia Bank, as well as the smaller colony of Washburn Junior in 2006. The 22 colonies in Florida Bay were distributed by region in the following way: 4 colonies in the Northwest, 6 colonies in the Northeast, 4 colonies in the Central, and 8 colonies in Southeast Florida Bay. Nestlings were banded any where between 5 days and 20 days of age. On the youngest chicks, we placed clay on the inner surface of the band to reduce its diameter and thereby stop the band from sliding over the joint. As the chicks age and their legs grow, this soft clay is then displaced, allowing the band to move freely. After approximately 20 days of age, we no longer attempted to band the nestlings due to their extreme mobility.

In Florida Bay, a total of 3 bands were placed on each nestling. A USGS band was placed on the tarsus, and a 2-digit alphanumeric band was placed on the opposite tibia. Florida Bay spoonbills received an additional colored celluloid band, placed above the alphanumeric band, to designate the region in which the bird was banded. Tampa Bay birds received a USGS band and a red alphanumeric band but did not receive an additional celluloid band. At the time of banding, we recorded the age and sibling rank of each chick and the number of siblings or eggs still in the nest.

Results

2003-2004 Spoonbill Nesting Season

Northwestern Sub-Region: Sandy Key

A new spoonbill nesting colony was discovered in 2003-2004 on Palm Key bringing the number of active colonies in the northwestern sub-region to five. Nest counts were made at all five colonies with a total of 250 nests (Table 3.1). Nesting success surveys were conducted at Sandy Key on Nov 21, 26, Dec 4, 12, 18, 22, 31, Jan 9, 16, 26, Feb 13, 21, Mar 19 and Apr 18. Individual nest attempts were remarkably asynchronous compared with previous years. We estimate that the first nest to lay eggs was on Nov 10 while the last nest didn't lay eggs until Jan 5. Usually, all nests are initiated within 14 to 21 days of each other. The mean egg laying date was Dec 2, and mean hatch date was Dec. 23 (based on previous years, the average nest initiation date is Nov 25). The 96 nests counted were well below the average (163 nests since 1984), and was the lowest recorded nest count since 1985. Forty-one nests were marked for revisitation. Of these, only 44% were successful at raising chicks to at least 3 weeks old (the time when they first leave the nest) with the average of 0.86 chicks per nest attempt (Table 3.2). Resighting data supported the nest monitoring estimate: the fate of 24 chicks banded at Sandy Key are known and 75% of these survived to become flighted juveniles (Table 3.3). The fledging rate was well below average (1.26 chicks/attempt since 1984; Table 3.2) and was only marginally successful (the standard for being considered a successful nesting is at least 1 chick fledged per nest on average). Total production for Sandy Key was estimated at a disappointing 82 chicks fledged. This estimate was confirmed by the observation of 50-75 chicks flying around the island on Jan 21. The only bright point was that of those nests that succeeded, the production rate was 1.94 chicks fledged per successful attempt, indicating that parents who were able to raise young did so at a high level of success.

A discussion of water levels and prey fish availability at the BL fish collection station is pertinent to understanding why spoonbills nesting in the Northwestern sub-region failed to achieve a higher degree of success. Lorenz (2000) estimated that prey fish become concentrated into small pools when water levels on the surrounding wetland drop to about 12.5 cm, thereby making them susceptible to predation by spoonbills and other wading birds. In Oct, water levels at BL were declining but remained well above the fish concentration threshold. Fish availability on the foraging site (i.e. the concentration of fish that a foraging wading bird would encounter) was estimated about 2g/m^2 of fish biomass. In mid-Nov water levels dropped below the concentration threshold of 12.5cm for the first time and fish density increased to 15g/m^2. This corresponds to a period of increased nest initiations at Sandy Key. Unfortunately, unseasonable rainfall events occurred in Dec and Jan causing reversals in the dry-down process and water levels fluctuated. We attribute the asynchronous nature of spoonbill nesting to these water level fluctuations. Available fish biomass during Dec and Jan were estimated to be well below average (Dec 2003=6.5g/m^2, Dec mean 1990-2002=25g/m^2; Jan 2004= 5.5g/m^2, Jan mean 1991-2003=40g/m^2). Given the mean hatch date of Dec 23, most chicks hatched when foraging conditions were relatively poor. For the six weeks post-hatching (when chicks are most susceptible to mortality), parental spoonbills likely experienced a relatively low degree of foraging success as a result of the low and fluctuating prey availability on proximal wetlands (as indicated by BL samples). This likely explains the high rate of nest failure and the below average success rate per nesting attempt. Over the course of Feb and Mar, water levels steadily declined with only minor reversals. Fish availability were estimated at 14 and 22g/m2 in these months, respectively. Those nests that survived the poor conditions in Dec and Jan found very good conditions in Feb and Mar, thereby explaining the high degree of production if only successful nests are taken into account.

Northeastern sub-region: Tern Key

All seven colonies in the northeastern sub-region were surveyed for nesting activity, however, only four were active with one of the active colonies having only 3 nests (Table 3.1). The 106 total nests in the sub-region was the second lowest nesting effort in terms of the number of active colonies since 1962 (last year's count was 101). Spoonbill nesting success surveys were conducted at Tern Key on Nov 18, Dec 2, 10, 17, 23, 31, Jan 8, 15, 22, 27, Feb 3, 11, 17, 24, Mar 2, 11, 19, 25, Apr 5, 11, 19, 27, and May 5. As has been the norm for the last several decades, there were two distinct nestings at Tern Key during the 2003-04 breeding cycle. During the first nesting, the first egg was laid on Dec 9 and the last nest initiated on Jan 10 with the mean laying date estimated at Dec. 23. The mean hatching date was Jan 13. As at Sandy Key, the nesting was asynchronous, but not as severe and the mean initiation date was much later than that of Sandy Key. As has been the trend in recent years, the first nesting effort was alarmingly small: only 83 nests compared to almost 200 nests ten years ago and over 500 nests twenty-five years ago. We believe this decline in northeastern Florida Bay is due to water management practices on the foraging ground. In addition to the alarmingly low nesting effort, the success rate was abysmal. On average, each nest attempt produced 0.15 chicks per nest, well below the average of 0.78 since 1984 (Table 3.2) and well below the pre-1980 average of 2.0 chicks/nest (Lorenz et al. 2002). This low rate is confirmed by banding results: the fates of 18 chicks banded on Tern Key are known and these had only an 11% survival rate (Table 3.3). Almost all of the nests failed (only 9% successful) and total production for the colony was estimated at only 6 chicks.

As at BL, water levels at the northeastern foraging grounds began to decline in Oct, but a rainfall event in early Nov resulted in a major reversal of dry-down patterns throughout the region. Water levels were actually higher mid-Nov than at the traditional peak of the wet season water levels in late Sep. A second rainfall event in mid-Dec also resulted in a reversal but was not as significant as the Nov event. These events combined kept water levels at foraging sites above the concentration threshold of 12.5 cm until early Jan. Similar to the western sub-region, these high water levels on the primary foraging grounds most likely explain the delay and the asynchronous nature in spoonbill nesting in the Northeastern sub-region. An analysis of fish collected at four sampling sites supports this conclusion. Maximum available prey biomass from all four sites (i.e., prey estimates from the site with the highest available biomass were used) was well below average in Nov and Dec (Nov 2003=3g/m^2, Nov mean 1990-2002=10g/m^2; Dec 2003= 9g/m^2, Dec mean 1990-2002=21g/m^2).

In Jan, prey availability was about average (Jan 2004=13g/m^2; Jan mean 1991-2003=16g/m^2) and in Feb it was lower than average but still relatively robust (Feb 2004=10g/m^2; Feb mean 1991-2003=17g/m^2). These data would indicate that post hatch foraging conditions would have been reasonably good for spoonbills, however, a reversal event was not captured by our fish sampling methodology. A small rainfall event resulted in water levels throughout the northeastern sub-region exceeding the 12.5cm threshold from Jan 18 to Jan 26. Although we did not collect any fish availability data during this period, previous analyses of our long-term data set indicate that fish would have dispersed across the wetland surface and would have been unavailable to predators such as spoonbills (Lorenz 2000). Fifty-eight percent of the nests at Tern Key failed during this 8-day period. This example demonstrates that use of data means (whether physical or biological) may miss important short-term episodic events that can actually have major implications for the ecosystems (see Bay-wide Synthesis for more). In the upcoming year, we intend to avoid this pitfall by sampling fish at JB (and possibly HC) once a week during the Tern Key post-hatch period.

The second wave of nesting at Tern Key was much more typical of a successful nesting. The nesting began in mid-March and exhibited the stereotypic synchronous nature of nesting spoonbills. The first eggs were laid on Mar 14 and the last nest initiated on Apr 5 with the mean laying date of Mar 23. The mean hatch date was Apr 13. This effort was smaller than the first nesting (64 nest) however 84% of the nests succeeded with an average of 1.38 chicks reaching 21d post-hatching per nest attempt. Of the successful nest, the average production was 2.09 chicks per nest. We estimate that 88 chicks fledged during the second nesting.

The Mar 23 mean hatch date coincided with a decline in water levels to their lowest point of the year on the foraging grounds. In Mar 2004, maximum available fish biomass from the four sampling sites was triple ($39 g/m^2$) that of the 13 year average (Mar mean 1991-2003=$13 g/m^2$). The first chicks of the second nesting hatched a few days after this measurement was collected. In Apr, fish availability declined ($16 g/m^2$) but still remained higher than the 13 year mean (Apr mean 1991-2003 $14 g/m^2$). These low water levels and high prey availability just prior to and following hatching indicate that above average foraging conditions coincided with the second nesting thereby likely explaining the high degree of success.

Southeastern Sub-Region: Middle Butternut Key

All of the 12 Southeastern colonies were surveyed for nesting activity (Table 3.1). Nesting success surveys were conducted at Middle Butternut Key on Nov 24, Dec. 9, 23, Jan. 2, 7, 13, 23, Feb 2, 6, 13, 19, 25, Mar 2, 8, 12, 17, 23, 29, Apr 7, 16, and May 6. The first egg was laid on approximately Dec 15, with a mean lay date of Dec 30. The mean hatch date was estimated to be Jan 19. Only 7 nests were initiated on the island, which matches the number of nests in 2003--the lowest ever recorded at Butternut Key since the colony first formed in 1984. This nesting effort was almost a complete failure, with a production rate of 0.14 chicks per nest attempt (the lowest since 1984; Table 3.2). Only one fledgling was observed flying about the island from Mar 8 through Mar 23. Historically, the southeastern colonies focused foraging on the mangrove wetlands on the mainline Florida Keys. Although most of these wetlands were filled by 1972 as part of Keys development boom, we presume (based on anecdotal evidence) that the few remaining Keys wetlands still serve as important foraging grounds for these birds. Since 1972 (when large scale filling of wetlands ended), nesting attempts in the Southeastern sub-region generally faired poorly: 5 of 8 years surveyed were failures. Based on these observations it appears that conditions during the 2004 nesting were typically poor in the Southeastern sub-region. Based on previous work (Lorenz et al. 2002) it appears that the quality of the Southeastern sub-region for nesting spoonbills is marginal at best thereby explaining the low overall effort. This is stark contrast to the period prior to the keys land boom when spoonbills nesting in the Southeastern sub-region successfully fledged young every year with an average production of >2 chicks per nest (Lorenz et al. 2002).

Central sub-region: east Bob Allen key

All six colonies in the Central sub-region were surveyed in 2003-04 (Table3.1). Nesting success surveys at East Bob Allen Key (EBA) were performed on Nov 24, Dec 8, 29, Jan 6, 12, 21, 29, Feb 17, Mar 9, 31, and Apr 20. Only nine nests were found on EBA, which is well below average (17 nests since 1984). Only one nest produced eggs; the first egg was laid on Dec. 14, and the first chick hatched on Jan 3. This nesting was a complete failure with 0 chicks per attempt. The only nest that produced eggs did not succeed in fledging any young (the lowest since 1984; Table 3.2).

Significant nesting in the Central sub-region is a relatively new phenomenon, having started in the mid-1980's. As such, little information has been collected on where these birds feed, but the central locations suggests that they may opportunistically exploit the primary resources used by the other sub-regions. Spoonbills nesting in the Central sub-region have reasonable access to the entire mosaic of foraging habitats found in the other four sub-regions (Figure 3.1). This catholic foraging style may cost a little more energetically (longer flights to foraging areas), but the increased likelihood in finding suitable foraging locations may counterbalance the cost. However, if the specific foraging habitats utilized by spoonbills in all of the other four sub-regions become compromised, the spoonbills of the Central sub-region would also be deleteriously affected (as in this year). This hypothesis will be tested in the future by making flight line observations and through following flights with fixed wing aircraft.

Southwestern sub-region: Buchanon Keys

All keys in the southwestern sub-region were surveyed multiple times in 2003-04 but only 2 nests were found on East Buchanon Key (Table 3.1). Although the Southwest sub-region did produce nests (unlike this sub-region in 2003), neither of these nests fledged any young.

<u>Bay-wide synthesis</u>

Bay-wide Roseate Spoonbills nest numbers were at their lowest since 1969-70 indicating a continued downward spiral that began with completion of these major water management structures in the early 1980's. Historically, the Northeastern sub-region was the most productive sub-region of the bay (Lorenz et al. 2002). Since 1982, this sub-region has been heavily impacted by major water control structures that lie immediately upstream from the foraging grounds (Lorenz 2000).

The foraging grounds associated with the Northwestern sub-region were of relatively moderate quality while those in the Northeastern and Southeastern sub-regions were of poor quality. Nest production rates in these sub-regions reflect these conditions with Sandy Key in the northwest experiencing moderate success and focal colonies in the northeast and central regions essentially experiencing a total failure. It is possible that the birds from the Central sub-region were flying the relatively long distances to. Northwest foraging grounds on Cape Sable, however, the extra travel time and energetic costs of the longer foraging flights, coupled with foraging in marginal quality habitat, may have manifested itself in zero nesting success (Table 3.2).

Our hydrologic data indicates that major rainfall events occurred in late September and late October of 2003. The result was major reversals in the drying patterns on the spoonbills primary foraging grounds (i.e. water levels began to decline before the events, but rapidly increased following the rain thereby resetting the drying patterns). In Dec, another rainfall event resulted in a significant reversal, although neither the rain nor the reversal were as severe as the September and October events. We believe that these reversals disrupted the cue for nesting (which is generally believed to be tied to water levels) thereby resulting in asynchronous and delayed nesting. We also believe that the long delay in nesting and the uncertainty of the cue caused the lower than usual nesting effort. Our hydrologic data from both the eastern and western foraging grounds suggest that this was a regional phenomenon. Furthermore, the timing and asynchronous nature of the spoonbill nesting efforts occurred in both the northeastern and northwestern bay. The observations indicate that this was a naturally occurring event and not a result of water management practices.

The spoonbill nest productivity in the northeastern bay was an order of magnitude lower than that of the northwestern bay. Since the eastern bay foraging grounds are directly affected by water management, and those in the west are only indirectly affected, these results suggest a possible negative impact of water management on spoonbills. Fifty-eight percent of the nests on Tern Key were abandoned between Jan 15 and Feb 3. In contrast, over the approximately same time period (Jan 16-Feb 5) Sandy Key only had 19% of its nests fail. We suspect that water management activities between Jan 15 and Feb 3 exacerbated an already bad situation for spoonbills nesting on Tern Key.

An examination of the rainfall data indicated that a small rainfall event (on the order of 1.25 cm) occurred on Jan 18 and 19. Although only a small amount of rain fell, the storm itself was spatially very large, covering a regional scale. Water levels at spoonbill foraging sites not affected by water management (e.g. western sites) increased 7cm. This represents the background impact of the rain due to run-off from upstream locations. Foraging sites affected by water management increased 15.5cm in the eastern bay. We attribute the difference in these water level increases to water management practices that divert unnaturally high amounts of water onto the foraging grounds. Furthermore, water levels on the impacted sites exceeded the point at which fish concentrated from Jan 18 to Jan 27. Although, no fish samples were collected during this period past analyses strongly suggest that this reversal resulted in the dispersal of prey and the high rate of nesting failure during this period.

This years observations that the nesting effort failed in the Northeastern sub-region while moderately successful in the Northwestern sub-region indicate that up-stream operations continue to damage the Florida Bay ecosystem. Overall, the 2003-04 nesting was generally poor for natural reasons, however, water management practices exacerbated the problems in the eastern bay resulting in an abysmal production rate compared to the western bay. These data suggest that Florida Bay will continue to decline in ecologic health unless major changes are made to water management practices that effect the region.

2003-2004 Spoonbill Banding Results

Florida Bay

In all, 162 Chicks were banded from 85 nests across Florida Bay. Of these 27% were presumed dead before leaving the nest and 20% were observed post fledging. Outside of their natal colonies, there have been no resightings of these birds nor any of the 30 birds banded in Florida Bay last year.

In the Northwestern sub-region, 78 nestlings from 38 nests within three colonies (Sandy, Frank, and Clive keys) were banded (Table 3.3). Chicks were banded between Dec 22 and Jan 21. Eight percent of these chicks were found or presumed dead before leaving their nest. Twenty-six percent of the banded chicks were observed post-fledging but before they abandoned their natal colony.

In the Northeastern sub-region, 49 nestlings from 27 nests within three colonies (Tern, N. Park and Duck keys) were banded (Table 3.3). Chicks were banded between Jan 8 and Feb 17. More than 45% of these chicks were found or presumed dead before leaving their nest. Only 8% of the banded chicks were observed post-fledging but before they abandoned their natal colony.

In the Central sub-region, we banded 14 nestlings from 7 nests within three colonies (E. Bob Allen, Jimmie Channel and Calusa keys; Table 3.3). Chicks were banded between Jan 12 and Feb 16. At least 46% of these chicks were found or presumed dead before leaving their nest. Eleven percent of the banded chicks were observed post-fledging but before they abandoned their natal colony.

In the Southeastern sub-region, we banded 21 nestlings from 13 nests within six colonies (East and Middle Butternut, Stake, Crab, East and Crane keys; Table 3.3). Chicks were banded between Jan 12 and Feb 19. More than 52% of these chicks were found or presumed dead before leaving their nest but 25% of the banded chicks were observed post-fledging but before they abandoned their natal colony.

Tampa Bay: Alafia Bank

Spoonbills nested in 8 colonies in the Greater Tampa Bay area this year. The largest colony in the region is Alafia Bank in Hillsborough Bay, with 320 pairs. A total of 330 fledged birds were observed during one survey of the Alafia Bank Colony this season.

We concentrated our banding efforts for the Tampa Bay area at Alafia Bank. We banded nestlings on April 9, 15, 22, 23, and 29. We banded 233 nestlings from 131 nests (Table 3.3). In 19 resighting surveys of the colony, 216 of the 233 banded chicks were observed as flighted juveniles. We have band recoveries for only 2 dead birds, and only 15 of the total birds banded have not been resighted at all. Based on our estimation of 1.65 fledged birds/nest (216 resighted nestlings/131 nests), we expect about 530 spoonbills (320 pairs X 1.65 birds/nest) fledged from Alafia Bank.

Discussion of 2003-2004 Banding Results

The high degree of mortality observed and the low resighting rate of banded spoonbill chicks before they abandoned their natal colony further demonstrates the poor conditions in Florida Bay. That 98% of the birds banded in Tampa Bay were resighted as flighted juveniles not only demonstrates that the techniques used were not harmful but that spoonbills are highly productive when conditions are appropriate for reproduction. It is also interesting to note that the rapid growth of spoonbill numbers at the Alafia Colony in Tampa Bay coincides with the rapid decline in spoonbill numbers in Florida Bay since the early 1980's. We will continue to band in both locations using Alafia Bank as control of sorts for Florida Bay as well as source of information on spoonbill demographics in Florida and the larger Gulf of Mexico and Caribbean geographical regions.

2004-2005 Spoonbill Nesting Season

Northwestern Sub-Region: Sandy Key

All five colonies in the Northwestern sub-region were surveyed for nesting activity in 2004-05 (Table 3.1). A total of 264 nests were counted in this sub-region, which is slightly above average for this region compared to the last twenty years of survey data. Nesting success surveys were conducted at Sandy Key on Oct 28, Nov 9, 23, Dec 3, 13, 19, 29, Jan 3, 12, 21, 27, Feb 4, Feb 15, and Mar 14. Individual nest attempts were asynchronous compared to this colony's historical nesting record; however, in the last few years, nest attempts have typically been asynchronous. We estimate that the first nest to lay eggs was on Nov 19 while the last nest didn't lay eggs until Dec 19. Usually, all nests are initiated within 14 to 21 days of each other. The mean egg laying date was Nov 30, and mean hatch date was Dec 20 (based on previous years, the average nest initiation date is Nov 18). The 155 nests counted were slightly below average (166 nests since 1984). Thirty-eight nests were marked for revisitation. Of these, an auspicious 74% were successful at raising chicks to at least 3 weeks old (the time when they first leave the nest) with the average of 1.08 chicks per nest attempt (Table 3.2). Resighting data supported the nest monitoring estimate: the fate of 131 chicks banded at Sandy Key are known and 60% of these survived to become flighted juveniles (Table 3.4). The fledging rate was below average (1.25 chicks/attempt since 1984; Table 3.2) but was considered successful (the standard for being considered a successful nesting is at least 1 chick fledged per nest on average). Total production for Sandy Key was estimated at an encouraging 167 chicks fledged (compared to last year's dismal 82 chicks fledged). This estimate was confirmed by the observation of a total of 120 banded fledglings outside the colony (Table 3.4).

A discussion of water levels and prey fish availability at the BL fish collection station is pertinent to understanding why spoonbills nesting in the Northwestern sub-region were successful. Lorenz (2000) estimated that prey fish become concentrated into small pools when water levels on the surrounding wetland drop to about 12.5 cm, thereby making them susceptible to predation by spoonbills and other wading birds. From Oct 19 to Nov 12 water levels rapidly declined from 32 cm relative depth to 6 cm, probably providing the stimulus for courtship activity. Water levels remained below the fish concentration threshold (FCT) of 12.5 cm through the mean nest initiation date of Nov 20. By the mean hatch date (Dec 20), relative water depth was -5cm indicating that the prey base was highly concentrated into the remaining wetted areas on the foraging ground. At this time available fish biomass was estimated to be relatively high at 6 g/m^2. During the critical 21 days post hatch period, water levels continued to recede to -10cm with available biomass estimated at 4.5g/m^2. By 42 days post-hatch (Jan 31), water levels had slightly increased to 0cm relative but fish remained highly concentrated. A storm event raised water levels above the FCT from approximately Feb 11-15 and available fish estimates dropped to 0.5 g/m^2. Fortunately, 8-10 week old chicks are more resilient to low food availability than 3 or 6-week old chicks and no mortality was documented during this event. Within a week following this event, water levels dropped back below 0cm relative depth and remained there through Mar and Apr. Fish samples collected in Mar and Apr indicated fish availability at about 7.5g/m^2. These conditions were ideal for fledging chicks from the natal colony, which occurred between Mar14 and Apr 7.

Northeastern Sub-Region: Tern Key

All seven colonies in the northeastern sub-region were surveyed for nesting activity, however, only three were active with one of the active colonies having only one nest (Table 3.1). The 108 total nests in the sub-region is not the lowest nesting effort in terms of the number of active colonies (2002-03 count was 101), but is still well below the average nesting effort of this region. Spoonbill nesting success surveys were conducted at Tern Key on Nov 5, 19, Dec 2, 16, 30, Jan 13, 20, 26, 31, Feb 3, 13, 22, Mar 1, 8, 22, 30, April 6, 14, 22, May 5 and 24. As has been the norm for the last several decades, there were two distinct nestings at Tern Key during the 2004-05 breeding cycle. During the first nesting, the first egg was laid on Dec 20 and the last nest initiated on Jan 12 with the mean laying date estimated at Dec 28. The mean hatching date was Jan 17. As at Sandy Key, the nesting was asynchronous. The mean initiation date was much later than that of Sandy Key. As has been the trend in recent years, the first nesting effort was alarmingly small: only 108 nests compared to almost 200 nests ten years ago and over 500 nests twenty-five years ago. We believe this decline in northeastern Florida Bay is due to water management practices on the foraging ground. In addition to the alarmingly low nesting effort, the success rate was abysmal. On average, each nest attempt produced 0.1 chicks per nest, well below the average of 0.72 since 1984 and well below the pre-

1980 average of 2.0 chicks/nest (Table 3.2). Almost all of the nests failed (only 3% successful) and total production for the colony was estimated at only 10 chicks.

As at BL, water levels at the northeastern foraging grounds began to decline in mid-Oct through mid-Dec, and dropped below the FCT for the first time in early Dec. Between Dec 20 and Dec 24, water levels at one of the fish sampling sites (HC) were at one of the lowest points for the year (0cm relative depth). Shortly thereafter, water levels began to rise and fluctuated back and forth across the FCT through mid-Jan. These fluctuating water levels occurred at about the mean nest initiation date of Dec 28, thereby possibly explaining the asynchronous nature of the nesting effort, i.e., many nests were initiated during the low water period of Dec 20-24, but the remaining nest attempts were staggered across the next few weeks as water levels fluctuated. At the time of the mean hatch date (Jan 17) the JB site was at its lowest water level of the year (-8cm) and fish availability was high across the landscape (mean of 7 $g/m^2$from three sites). Had conditions remained this favorable, the nesting attempt would likely have succeeded. Unfortunately, within one week (Jan 23) water levels increased to 17cm relative depth, well above the FCT of 12.5 cm. Fish availability dropped to 1.8 g/m^2 at a time when chicks were most vulnerable (on average, less than one week old). Water level remained above the FCT across the landscape through mid-Feb. By early Feb, there were only 3 active nests within the colony. Of interest is that the only nest that succeeded to 21 days post-hatch was the earliest nest initiated in our survey. These chicks were near 21d when water levels increased in mid-Jan, indicating that these chicks were hatched under more favorable conditions than the rest of the colony.

The second wave of nesting at Tern Key was more successful than the dismal first nesting attempt, but was much more disappointing than previous years' second nesting attempts. The nesting began in mid-March but still exhibited somewhat asynchronous timing of nest initiation. The first eggs were laid on Mar 10 and the last nest initiated on Mar 31 with the mean laying date of Mar 23. The mean hatch date was Apr 12. This effort was much smaller than the first nesting (about 35 nests) however 44% of the nests succeeded with an average of .48 chicks reaching 21d post-hatching per nest attempt. Of the successful nests, the average production was 1.08 chicks per nest. We estimate that only 17 chicks fledged during the second nesting. During the second nesting, water levels on the northeastern foraging grounds continued to fluctuate rapidly across the FCT with resultant low fish availability for significant periods of time (3-7 days)--thereby explaining the nesting failure.

Southeastern Sub-Region: Middle Butternut Key

All of the 12 Southeastern colonies were surveyed for nesting activity (Table 3.1). Nesting success surveys were conducted at Middle Butternut Key on Nov 2, 16, 30, Dec 16, 22, 31, Jan 7, 14, 21, 27, Feb 2, 9, 18, 25, Mar 11, and 21. The first egg was laid on approximately Dec 14, with a mean lay date of Dec 24. The mean hatch date was estimated to be Jan 13. Only 9 nests were initiated on the island, which is slightly better than the two previous years' nest attempts (7 nests). On average, each nest attempt produced 1.11 chicks per nest attempt; this is dramatically better than last year's almost complete failure, and is well above the average .98 chicks per nest since 1984. However, only two fledglings were observed flying about the island from Feb 18 through Mar 11.

Historically, the southeastern colonies focused foraging on the mangrove wetlands on the mainline Florida Keys. Although most of these wetlands were filled by 1972 as part of Keys development boom, we presume (based on anecdotal evidence) that the few remaining Keys wetlands still serve as important foraging grounds for these birds. Since 1972 (when large scale filling of wetlands ended), nesting attempts in the Southeastern sub-region generally faired poorly: 5 of 9 years surveyed were failures. Based on these observations it appears that conditions during the 2004 nesting were above average in the Southeastern sub-region. However, based on previous work (Lorenz et al. 2002) it appears that the quality of the Southeastern sub-region for nesting spoonbills is marginal at best thereby explaining the low overall effort. This is stark contrast to the period prior to the keys land boom when spoonbills nesting in the Southeastern sub-region successfully fledged young every year with an average production of >2 chicks per nest (Lorenz et al. 2002).

Central Sub-Region: East Bob Allen Key

All six colonies in the Central sub-region were surveyed in 2004-05 (Table 3.1). Nesting success surveys at East Bob Allen Key (EBA) were performed on Oct 26, Nov 11, 24, 29, Dec 14, 28, Jan 11, 12, 19, 25, Feb 2, 10, 15, 23, Mar 7, 17, and 29. Only 8 nests were found on EBA, which is well below average (16 nests since 1984). The first egg was laid on Dec. 16, and the last nest initiated on Jan 8 with the mean laying date estimated at Dec 29. The mean hatching date was Jan 18. Although this nesting effort was not a complete failure like last year (0 chicks per nest attempt), it was well below the average and produced only .43 chicks per nest attempt. Only 20% of the nests were successful and the total production for the colony was estimated at only 3 chicks. Significant nesting in the Central sub-region is a relatively new phenomenon, having started in the mid-1980's. As such, little information has been collected on where these birds feed but the central locations suggests that they may opportunistically exploit the primary resources used by the other sub-regions. Spoonbills nesting in the Central sub-region have reasonable access to the entire mosaic of foraging habitats found in the other four sub-regions (Figure 3.1). This catholic foraging style may cost a little more energetically (longer flights to foraging areas), but the increased likelihood in finding suitable foraging locations may counterbalance the cost. However, if the specific foraging habitats utilized by spoonbills in all of the other four sub-regions become compromised, the spoonbills of the Central sub-region would also be deleteriously affected (as in this year). This year, fixed wing aircraft followed one adult spoonbill from the Central sub-region to its foraging grounds over 10 miles and 30 minutes away. If these foraging grounds do not support abundant and concentrated prey, such a long flight may be too energetically demanding for a spoonbill to make, resulting in lower nest success. This hypothesis will be tested in the future through more following flights with fixed wing aircraft.

Southwestern Sub-Region: Barnes Key

All keys in the southwestern sub-region were surveyed multiple times in 2004-05 but only 1 nest was found on Barnes Key (Table 3.1). This is the first time since 1963 that a spoonbill has nested at Barnes Key. This nest did produce young, and one chick was observed post 21-day hatching. This is a promising find for the Southwest sub-region, whose historic record high was 153 nests in 1979.

Bay-wide synthesis

Bay-wide Roseate Spoonbills nest numbers were below average, indicating a continued downward spiral that began with completion of these major water management structures in the early 1980's. Historically, the Northeastern sub-region was the most productive sub-region of the bay (Lorenz et al. 2002). Since 1982, this sub-region has been heavily impacted by major water control structures that lie immediately upstream from the foraging grounds (Lorenz 2000).

The foraging grounds associated with the Northwestern sub-region were of relatively high quality while those in the Northeastern and Southeastern sub-regions were of poor quality. Nest production rates in these sub-regions reflect these conditions with Sandy Key in the northwest experiencing nest success and focal colonies in the northeast and central regions essentially experiencing a total failure. It is possible that the birds from the Central sub-region were flying the relatively long distances to the Northwest foraging grounds on Cape Sable, however the extra travel time and energetic costs of the longer foraging flights, coupled with foraging in marginal quality habitat, may have manifested itself in low nesting success (Table 3.2).

Spoonbill nest productivity was considered successful in the western bay, while the eastern bay was almost a complete failure. Since water management practices directly affect the foraging grounds in the eastern bay, and those in the west are only indirectly affected, these results suggest a possible negative impact of water management on spoonbills.

This years observations that the nesting effort failed in the Northeastern sub-region while successful in the Northwestern sub-region indicate that upstream operations continue to damage the Florida Bay ecosystem. Overall, the 2004-05 nesting was generally poor compared to average nest success over the years, however, water management practices exacerbated the problems in the eastern bay resulting in an abysmal production rate compared to the western bay. These data suggest that Florida Bay will continue to decline in ecologic health unless major changes are made to water management practices that affect the region.

2004-2005 Spoonbill Banding Results

Florida Bay

In all, 415 chicks were banded from 186 nests across Florida Bay. Of these, 11% were observed dead either before leaving the nest or outside the colony and 45% were observed alive post-fledging. Outside of their natal colonies, there has been one resighting of a bird banded at Sandy Key in December observed at Shark Valley, Everglades National Park, in February. Two fledglings arrived at two wildlife rehabilitation centers in the Florida Keys, but both later died.

In the Northwestern sub-region, 271 nestlings from 119 nests within 4 colonies (Sandy, Frank, Clive, and Palm Keys) were banded (Table 3.4). Chicks were banded between Dec 19 and Jan 21. 4% of these chicks were found dead before leaving their nest. Approximately 50% of the banded chicks were observed post-fledging.

In the northeastern sub-region, 34 nestlings from 18 nests within 2 colonies (Tern and North Nest Keys) were banded (Table 3.4). Chicks were banded between Jan 20 and April 22. More than 23% of these chicks were found dead before leaving their nest. Only 35% of the banded chicks were observed post-fledging but before they abandoned their natal colony.

In the Central sub-region, we banded 30 nestlings from 15 nests within 4 colonies (E. Bob Allen, Jimmie, Calusa, and South Park Keys, Table 3.3). Chicks were banded between Jan 12 and Jan 21. At least 40% of these chicks were found dead before leaving their nest. Approximately 23% of the banded chicks were observed post-fledging but before they abandoned their natal colony.

In the Southeastern sub-region, we banded 80 nestlings from 34 nests within 5 colonies (M. Butternut, Stake, Pigeon, East, and Crane Keys, Table 3.3). Chicks were banded between Jan 12 and Jan 19. More than 18% of these chicks were found dead before leaving their nests but approximately 39% of the banded chicks were observed post-fledging but before they abandoned their natal colony.

Tampa Bay: Alafia Bank

Spoonbills nested in 5 colonies in the Greater Tampa Bay area this year. The largest colony in the region is Alafia Bank in Hillsborough Bay, with approximately 200 pairs. Therefore, we concentrated our banding efforts for the Tampa Bay area at Alafia Bank. We banded 105 nestlings from 58 nests (Table 3.4) during three banding sessions (Apr 1, 12, and 29). Out of the 105 nestlings banded, we have resighted 89 of them alive during 14 resighting surveys of the colony. We do not have any band recoveries for dead birds so the fate of the 16 banded birds is unknown, however, given the conspicuous nature of banded fledglings at Alafia Bank, it seems likely that these chicks did not survive. The mean ratio of marked to unmarked chicks during our resighting surveys was 32.7%. This suggests that the total number of chicks fledged at Alafia was approximately 372 (89 resighted banded chicks made up about 32.7% of the total fledgling population). This suggests a production of approximately 1.9 chicks per nest attempt (376 fledges from 200 nests).

Discussion of Banding Results

The high degree of mortality observed and the low resighting rate of banded spoonbill chicks before they abandoned their natal colony further demonstrates the poor conditions in Florida Bay. That 85% of the birds banded in Tampa Bay were resighted as flighted juveniles not only demonstrates that the techniques used were not harmful but that spoonbills are highly productive when conditions are appropriate for reproduction. It is also interesting to note that rapid growth of spoonbill numbers at the Alafia Colony in Tampa Bay coincides with the rapid decline in spoonbill numbers in Florida Bay since the early 1980's. We will continue to band in both locations using Alafia Bank as control of sorts for Florida Bay as well as source of information on spoonbill demographics in Florida and the larger Gulf of Mexico and Caribbean geographical regions.

2005-2006 Spoonbill Nesting Season

Northwestern Region: Sandy Key

All five colonies in the Northwestern region were surveyed for nesting activity in 2005-06 (Table 3.1). A total of 262 nests were counted in this region, which is slightly above average for this region compared to the last twenty years of survey data. Nesting success surveys were conducted at Sandy Key on Nov 11, 26, Dec 5, 15, 22, 29, Jan 4, 13, 20, Feb 2, 10, 16, 28, and Mar 27. Individual nest attempts were asynchronous compared to this colony's historical nesting record; however, in the last few years, nest attempts have typically been asynchronous. We estimate that the first nest to lay eggs was on Nov 13 while the last nest did not lay eggs until Dec 7. Usually, all nests are initiated within 14 to 21 days of each other. The mean egg laying date was Nov 26, and mean hatch date was Dec 16 (based on previous years, the average nest initiation date is Nov 18). The 120 nests counted were slightly below average (166 nests since 1984). Fifty-seven nests were marked for revisitation. Of these, 61% were successful at raising chicks to at least 3 weeks old (the time when they first leave the nest) with the average of 1.33 chicks per nest attempt (c/n; Table 3.2). The fledging rate was above average (1.25 chicks/attempt since 1984; Table 3.2) and is considered successful (the standard for being considered a successful nesting is at least 1 chick fledged per nest on average). Total production for Sandy Key was estimated at 160 chicks fledged (slightly lower than last year's 167 chicks fledged).

The results of the colony surveys were supported by results from the banding program. One hundred fifty-nine nestlings from 58 nests were banded at the Sandy Key colony (Table 3.3). Chicks were banded between Dec 15 and Dec 29. Although 18% of these chicks were found dead before leaving their nest, approximately 50% of the banded chicks were observed post-fledging on the fringes of the colony. Based on band resightings, nesting success was estimated to 1.31 c/n.

A discussion of water levels and prey fish availability at the BL fish collection station is pertinent to understanding why spoonbills nesting in the Northwestern region was successful. Lorenz (2000) estimated that prey fish become concentrated into small pools when water levels on the surrounding wetland drop to about 12.5 cm, thereby making them susceptible to predation by spoonbills and other wading birds. Water levels at the BL site peaked at >60cm following landfall of Hurricane Wilma on Oct 24, 2005. Within days, the water level receded rapidly to 20cm followed by a period characterized by a more gradual recession rate that was typical of November draw downs. Water levels reached the fish concentration threshold (FCT) of 12.5 cm on Nov 16 and remained below the FCT for the entire nesting cycle. By the mean hatch date (Dec 16) water was -3cm indicating that the prey base was highly concentrated into the remaining wetted areas on the foraging ground. At this time available fish biomass was estimated to be at its highest point of the year for this location. During the critical 21 days post hatch period, water levels remained below 0cm suggesting ideal foraging conditions. By 42d post hatch (early Feb), water levels had dropped to their lowest level of the year (-15cm) and our data indicates that fish continued to remain highly available to wading birds. Fish samples collected in Mar and Apr indicated fish continued to remain highly available, although there was a steady decline from Feb to Apr. Overall, conditions were ideal for fledging chicks from the Northwestern colonies, which occurred between in Mar and early Apr.

Northeastern Region: Tern Key

A new spoonbill nesting colony was discovered on Deer Key bringing the number of colonies in the northeastern region to eight, and the total number of nests to 127 (Table 3.1). Nest counts were made at all eight colonies, however; only five were active with one of the active colonies having only one nest (Table 3.1). The 127 total nests in the region is not the lowest nesting effort in terms of the number of active colonies (2002-03 count was 101), but is still well below the average nesting effort of this region. Spoonbill nesting success surveys were conducted at Tern Key on Nov 3, 21, Dec 2, 9, 19, 27, Jan 3, 10, 17, 24, 31, Feb 7, 14, 23, Mar 9, 16, 23, 28, April 10, 19, 26, and May 12. As has been the norm for the last several decades, there were two distinct nesting cycles at Tern Key during the 2005-06 breeding cycle. During the first nesting, the first egg was laid on Nov 22 and the last nest initiated on Dec 18 with the mean laying date estimated at Nov 28. The mean hatching date was Dec 18. As at Sandy Key, the nesting was asynchronous. The mean initiation date was slightly later than that of Sandy Key. As has been the trend in recent years, the first nesting effort was alarmingly small: only 106 nests compared to almost 200 nests ten years ago and over 500 nests twenty-five years ago. We believe this decline in northeastern Florida Bay is due to water management practices on the foraging grounds. In spite of this low nesting effort, the success rate was very good. On average, each nest attempt produced 1.61 c/n, well above the average of 0.79 since 1984 and only marginally lower than the pre-1980 average of 2.0 chicks/nest (Table 3.2). Of the 106 nests, 51 were marked for revisitation. Of these, an encouraging 63% were successful at raising chicks to at least 3 weeks old. This is a remarkable improvement from last year's nesting season (3% successful with 0.1 chicks per nest). Total production for the colony was estimated at 170 chicks.

In the northeastern region, 118 nestlings from 33 nests within 5 colonies (Tern, South Nest, North Nest, North Park, and Deer Keys) were banded (Table 3.5). Chicks were banded between Dec 19 and April 26. Unlike most other colonies where fledges roost conspicuously on the fringing trees prior to leaving the colony, fledges at the Northeastern colonies prefer to roost around myriad ponds and salt flats within the colony where they are harder to spot. Only 26% of the banded chicks were observed post-fledging but before they abandoned their natal colony for an estimated production of 0.97c/n, well below that estimated by the colony surveys. However, during visits to the colony, observers noted up to 100 unbanded fledglings around the island, which would support the high estimate for chick production. Furthermore, only 7% of the banded chicks were found dead before leaving their nest, further supporting the colony count estimate of 1.61 c/n.

As occurred at BL, water levels on the Northeastern foraging grounds receded rapidly immediately after Hurricane Wilma then more gradually after Nov 1. Three water level recorders in the C-111 basin indicated that water levels reached the FCT just prior to the mean nest initiation date of Nov 28. Three additional water level recorders in the Taylor Slough basin indicated that the FCT was reached just before the mean hatch date of Dec 18. Cumulatively, these recorders documented a drying front that moved from the northeast to the southwest sequentially drying wetlands on the foraging grounds. This creates ideal conditions for nesting spoonbills as the drying front moves closer to the colonies as the energetic demands of the chicks increase. Fish collections made at all six sites indicate highly concentrated prey throughout the nesting period. The prey became available in the C-111 Basin in Nov and dropped in Feb. In the Taylor Slough Basin fish became highly available in Dec and increased to a peak in Mar. The nearly ideal water recession resulted in a temporally and spatially picture-perfect scenario in making prey available to nesting spoonbills, thereby explaining the highest nesting success that had occurred in the Northeastern region since 1992.

The ideal water level recession that occurred at BL suggested that conditions should be excellent in the Northeastern region given minimal impact of water management practices. Water management can affect the recession rate in several ways (Lorenz 2006). For example, reversals in the recession rate release the concentration effect that low water has on the prey base. Maintaining artificially high water levels throughout the nesting cycle may also prevent fish concentrations from forming. Finally a too rapid recession rate tends to strand the prey base before they can seek out refugia from the drying front. This results in prey mass mortality and poor foraging conditions later in the nesting cycle. Given the low rainfall conditions following Hurricane Wilma, this was the main consideration that could cause failure during the 2005-2006 nesting cycle. Weekly conversations between the first author and Paul Linton, hydrologist for the SFWMD, were designed to prevent practices that may have endangered the nesting activities in Northeastern Florida Bay. The result of these conversations was a gradual scaling back of water releases into the Taylor Slough headwaters. Establishing whether there was a causal relationship between this practice and near perfect recession rates observed at six locations within the C-111 and Taylor Slough basins will be the subject of a future report.

The second wave of nesting at Tern Key was not as successful as the first nesting attempt. The nesting began in mid-March but still exhibited somewhat asynchronous timing of nest initiation. The first eggs were laid on Mar 14 and the last nest initiated on April 1 with the mean laying date of Mar 22. The mean hatch date was Apr 11. This effort was much smaller than the first nesting (about 20 nests). The small number of nests during the second nesting supports the hypothesis that second nesting is populated by birds that failed to produce young in the primary nesting. Since the phenomena began in the mid-1980s, the second nesting at Tern Key is larger than the primary nesting when there is bay-wide failure of the primary nesting. Likewise, in years when the primary nesting is successful (as was the case this year), the second nesting is typically small.

In 2006, the second nesting yielded only one successful nest with an average of 0.05 chicks reaching 21d post-hatching per nest attempt. We estimate that only 1 chick fledged during the second nesting. In early April, just before the mean hatch date, water levels increased to well above the FCT in the Taylor Slough Basin and in the C-111 basin, water levels periodically exceed the FCT for periods of several days. Although no fish data were collected during this period, Lorenz (2000) demonstrated that under these conditions, prey dispersed and become unavailable, thereby likely explaining the failure of the second nest attempt.

Southeastern Region: Middle Butternut Key

All of the 12 Southeastern colonies were surveyed for nesting activity (Table 3.1). Nesting success surveys were conducted at Middle Butternut Key on Nov 4, 28, Dec 6, 12, 23, 29, Jan 6, 12, 19, 27, Feb 3, 10, 17, Mar 4, and 22. The first egg was laid on approximately Nov 19, with a mean lay date of Nov 26. The mean hatch date was estimated to be Dec 16. Only 17 nests were initiated on the island, which is slightly better than the previous years' nest attempts (average of 8 nests). On average, each nest attempt produced 0.86 c/n; a marginal success rate. In the Southeastern region, we banded 111 nestlings from 46 nests within 5 colonies (M. Butternut, Stake, Pigeon, East, Crane, and Bottle Keys, Table 3.5). Chicks were banded between Dec 14 and Jan 9. More than 17% of these chicks were found dead before leaving their nests and approximately 31% of the banded chicks were observed post-fledging but before they abandoned their natal colony. Based on the banding effort, the success rate in the Southeastern region was 0.74, supporting the marginal success rate that was found at Middle Butternut Key.
The success rate observed via nest surveys is lower than last year's successful year of 1.11 chicks/nest attempt, and is slightly below the average 0.97 c/n since 1984. Historically, the southeastern colonies focused foraging on the mangrove wetlands on the mainline Florida Keys. Although most of these wetlands were filled by 1972 as part of

Keys development boom, we presume (based on anecdotal evidence) that the few remaining Keys wetlands still serve as important foraging grounds for these birds. Since 1972 (when large scale filling of wetlands ended), nesting attempts in the Southeastern region generally faired poorly: 6 of 10 years surveyed were failures (Table 3.1). Based on these observations it appears that conditions during the 2005-06 nesting were typically poor in the Southeastern region. However, based on previous work (Lorenz et al. 2002) it appears that the quality of the Southeastern region for nesting spoonbills is marginal, at best, thereby explaining the low overall effort. This is in stark contrast to the period prior to the Keys land boom when spoonbills nesting in the Southeastern region successfully fledged young every year with an average production of >2 chicks per nest (Lorenz et al. 2002).

Central Region: Calusa Key

Previous nest success surveys in this region were conducted on East Bob Allen Key (EBA). This year, the astonishingly low overall effort of nest production at EBA confirmed our need to begin surveying another, more representative colony in this region. Calusa Key will continue to be monitored as the focal colony for this region indefinitely. All six colonies in the Central region were surveyed in 2005-06 (Table 3.1). Nesting success surveys at Calusa Key were performed on Nov 9, 23, 30, Dec 8, 14, 21, 28, Jan 5, 11, 19, 26, Feb 1, 9, 16, 25, and Mar 27. Seventeen nests were found on Calusa, which is well above average (9.8 nests since 1984). The first egg was laid on Nov 7, and the last nest initiated on Dec 7 with the mean laying date estimated at Nov 21. The mean hatching date was Dec 11. This nesting effort was a complete success with 1.71 chicks per nest attempt, and 86% of the nests were successful at raising chicks to at least 3 weeks of age. Total production for the colony was estimated at 24 chicks, and this estimate was confirmed with the observation of 18 fledglings outside the colony (Table 3.3). Eighteen of the 19 chicks banded from 9 nests on Calusa Key confirming the high nest production estimated by nesting surveys.

We banded 117 nestlings from 50 nests within 4 colonies (E. Bob Allen, Jimmie, Calusa, and South Park Keys, Table 3.5) in the Central region. Chicks were banded between Dec 8 and Jan 5. Approximately 56% of the banded chicks were observed post-fledging but before they abandoned their natal colony. The banding effort estimate for production was 1.31 c/n, well below the survey estimate. However, several of these colonies are similar to those of the Northeastern region where fledges are not as conspicuous before they leave the colony. That only 4% of these chicks were found dead before leaving their nest suggests that the resighting technique may result in undercounts of the total number of banded birds that were successful.

Significant nesting in the Central region is a relatively new phenomenon, having started in the mid-1980's. As such, little information has been collected on where these birds feed but the central locations suggests that they may opportunistically exploit the primary resources used by the other regions. Spoonbills nesting in the Central region have reasonable access to the entire mosaic of foraging habitats found in the other four regions (Figure 3.1). This catholic foraging style may cost a little more energetically (longer flights to foraging areas), but the increased likelihood in finding suitable foraging locations may counterbalance the cost. However, if the specific foraging habitats utilized by spoonbills in all of the other four regions become compromised, the spoonbills of the Central region would also be deleteriously affected. This year, fixed wing aircraft followed one adult spoonbill from the Central region to its foraging grounds over 10 miles and 30 minutes away. If these foraging grounds do not support abundant and concentrated prey, such a long flight may be too energetically demanding for a spoonbill to make, resulting in lower nest success. However, based on a flight-line count and fixed-wing aircraft observations, it appeared that the birds from the Central region were flying over the Russell and Black Betsy Keys to the Taylor Slough area, where they were met with quality foraging habitat. This would support their exceptional nest success (Table 3.2).

Southwestern Region: Twin Keys

All keys in the southwestern region were surveyed multiple times in 2005-06 but only 1 nest was found on Twin Key (Table 3.1). This is the first time since 1998 that a spoonbill has nested at Twin Key. This nest did produce young, and one chick was observed post 21day hatching. This is a promising find for the Southwest region, whose historic record high was 153 nests in 1979.

Bay-wide Synthesis

Bay-wide Roseate Spoonbills nest numbers were below average, indicating a continued downward spiral that began with completion of these major water management structures in the early 1980s. Historically, the Northeastern region was the most productive region of the bay (Lorenz et al. 2002). Since 1982, this region has been heavily impacted by major water control structures that lie immediately upstream from the foraging grounds (Lorenz 2000). This year, the success rate at Tern Key was the highest it has been in 14 years and well above the 0.79 c/n average since 1982. The success of nesting attempts in the Northwestern region indicated that conditions should have been good for spoonbills nesting in the Northeastern region in the absence of adverse water management practices. The coordination between ecologists and water managers may have been beneficial through avoiding adverse management practices. Regardless, conditions were excellent on the Northeastern foraging grounds and the lack of adverse management practices resulted in a highly successful nesting in that region. Repeating such cooperation between ecologists and managers in the upcoming years will reveal how successful such communications are in providing the appropriate conditions for all fauna that utilize this wetland during the draw down process.

Based on a flight-line count and fixed-wing aircraft observations, it appeared that the birds from the Central region were flying over the Russell and Black Betsy Keys to the Taylor Slough area, where they were met with quality foraging habitat. This would support their exceptional nest success (Table 3.2).

In all, 472 chicks were banded from 187 nests across Florida Bay. Of these 13% were observed dead either before leaving the nest or outside the colony and 44% were observed alive post-fledging. Outside of their natal colonies, there has been one resighting of a bird banded at Sandy Key in December observed foraging at Lake Ingraham, Everglades National Park, in March.

2005-2006 Spoonbill Banding Results

In Florida Bay, spoonbill nestlings were banded at 16 out of the 22 colonies at which spoonbills nested. In Tampa Bay, we banded spoonbills at the largest colony in the region, Alafia Bank, as well as the smaller colony of Washburn Junior. The 16 colonies in Florida Bay were distributed by region in the following way: 1 colony in the Northwest, 5 colonies in the Northeast, 4 colonies in the Central, and 6 colonies in Southeast Florida Bay. The Northwest region did have 5 active nesting colonies; however, 4 of them were heavily patrolled by American crows, and we have seen nest predation in the past as a result of time spent banding nestlings in the colony. Due to that fact, we decided to abandon banding the other four colonies in that region. Although the Southwest region did have 1 nest, the nest was inaccessible to banding.

Comparison to Tampa Bay Nesting Population

We began banding spoonbill nestlings at Alafia Bank, Tampa Bay in 2003 as part of a pilot study for the banding program. The goals of this program were two-fold: 1) to determine the movements of spoonbills within the state and the region and 2) to get estimates of nesting success to compare to Florida Bay. Reports of spoonbills producing greater than 2 c/n in Florida Bay were regularly reported throughout Florida Bay as late as the early 1970s. Following the destruction of wetlands in the Keys and water diversion in the northeastern part of Florida Bay, the average dropped below 1 c/n on average. Tampa colonies provided an opportunity to see how productive spoonbills were in another part of the state to assess if this decline was unique to Florida Bay or a more regional response in general. Answering this question is critical to demonstrating the causal relationships between Everglades management and the observed decline in Florida Bay.

Spoonbills nested in 11 colonies in the greater Tampa Bay area this year. The largest colony in the region is the Richard T. Paul Alafia Bank Bird Sanctuary in Hillsborough Bay, with 360 pairs. The colony of Washburn Junior was the second largest with 53 pairs. A total of 294 fledged birds were observed during one survey of the Alafia Bank colony this season.

We concentrated our banding efforts for the Tampa Bay area at the Alafia Bank and Washburn Junior colonies. We banded nestlings on April 5, 11, 12, 13, 18, 19, 20, and 24. At Alafia, we banded 230 nestlings from 97 nests (Table 3.5) during 6 banding sessions (April 12, 13, 18, 19, 20, and 24). Out of the 230 nestlings banded, we have resighted 196 of them alive in 12 resighting surveys of the colony. One bird was observed dead in the colony, and one bird was found dead after being hit by a car in Flagler County (~150 miles away) only 2 months after it was banded at Alafia. Only 30 of the total birds banded have not been resighted at all. Based on our estimation of 2.02 fledged birds/nest (196 resighted nestlings/97 nests), we expect about 730 spoonbills (360 pairs X 2.02 birds/nest) fledged from Alafia Bank. At Washburn Junior, we banded 34 nestlings from 11 nests. Out of the 34 nestlings banded, we have resighted 29 of them alive in 8 resighting surveys. We do not have any band recoveries for dead birds, and 5 of the total birds banded have not been resighted at all. Based on our estimation of 2.64 fledged birds/nest (29 resighted nestlings/11 nests), we expect about 140 spoonbills (53 pairs X 2.64 birds/nest) fledged from Washburn Junior. Using an average production rate for the two colonies and applying it to the total number of nests in the Tampa region yields a total production of more than 1300 fledglings from Tampa Bay compared to 745 fledged from Florida Bay even though the number of nests was nearly identical (565 in Florida Bay, 566 in Tampa Bay). This comparison is telling in that, based on recent history, the 2005-06 nesting in Florida Bay was one of the best since 1982 and the nesting success in Tampa Bay was a little below average for this region.

We banded 164 birds in April 2003, 233 birds in 2004, and 105 birds in 2005. Since then we have received resight reports for over 90 of those birds. These birds were resighted in Brevard, Duval, Hendry, Hillsborough, Lee, Nassau, Palm Beach, Pasco, Pinellas, Polk, Sarasota, St. John's, and Taylor Counties. Banded birds have frequently been observed at Merritt Island, Ding Darling and Loxahatchee National Wildlife Refuges. Of those resighted birds, 5 birds were observed in Georgia. Three birds were observed in the same location in both 2004 and 2005. Three birds were observed in two different locations within the same year. Of the 110 resighting reported from across the state, 103 were birds banded in Tampa Bay and only 7 were banded in Florida Bay. This further suggests that Florida Bay's productivity is greatly diminished, however, migrations from Florida Bay southward to Cuba and the Yucatan Peninsula cannot be discounted as a cause for the low resightings from Florida Bay. Clearly, Florida Bay has been, and continues to be, impacted by anthropogenic forces that render production be less than that of healthy spoonbill nesting areas including the highly industrialized habitats of Tampa Bay. It is also interesting to note that rapid growth of spoonbill numbers in Tampa Bay coincides with the rapid decline in spoonbill numbers in Florida Bay since the early 1980's. We will continue to band in both locations using Alafia Bank as a pseudo-control for Florida Bay, as well as a source of information on spoonbill demographics in Florida and the larger Gulf of Mexico and Caribbean geographical regions.

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Table 3.1. Number of ROSP nests in Florida Bay Nov - May in the 2003-2004, 2004-2005, and 2005-2006 nesting seasons. An asterisk (*) indicates colony with nesting success surveys (see Table 3.2).

Region	Colony	2003-04	2004-05	2005-06	Summary since 1984		
					Min	Mean	Max
Northwest	Sandy*	96	155	120	62	160	250
	Frank	111	77	93	0	54	125
	Clive	22	11	38	11	22	38
	Palm	21	20	2	0	6.87	45
	Oyster	0	1	9	9	16.67	21
	Subtotal	250	264	262	65	211.24	325
Northeast	Tern*	83	101	106	60	111.48	184
	N. Nest	0	1	1	0	0.14	1
	S. Nest	3	0	10	0	18.13	59
	Porjoe	0	0	0	0	31.17	118
	N Park	10	6	8	0	19.44	50
	Duck	10	0	0	0	2.13	13
	Pass	0	0	0	0	0.57	4
	Deer			2	2	2.00	2
	Subtotal	106	108	127	101	190.88	333
Central	Calusa*	15	11	17	0	9.80	15
	E. Bob						
	Allen*	9	8	2	0	16.40	35
	Manatee	0	0	0	0	0.00	0
	Jimmie Channel	14	26	25	6	20.67	47
	Little Pollach	0	0	0	0	3.67	13
	S. Park	1	14	23	0	11.00	39
	Subtotal	39	59	67	15	53.87	96
Southwest	E. Buchanon	2	0	0	0	7.00	27
	W. Buchanon	0	0	0	0	3.92	9
	Barnes	0	1	0	0	0.08	1
	Twin	0	0	1	0	1.85	8
	Subtotal	2	1	1	0	11.38	35
Southeast	M. Butternut*	7	9	14	7	23.60	66
	Bottle	2	0	10	0	11.29	40
	Stake	3	2	13	0	3.85	19
	Cowpens	0	0	0	0	3.58	15

	Cotton	0	0	0	0	0.00	0
	West	0	2	0	0	3.58	9
	Low	0	0	0	0	0.00	0
	Pigeon	6	56	26	0	8.15	56
	Crab	4	1	0	0	2.00	8
	East	8	13	5	0	3.71	12
	Crane	8	2	21	8	13.77	27
	E. Butternut	4	0	1	4	4.25	11
	Subtotal	42	85	90	39	82.54	117
Florida Bay Total		439	517	547	429	565.00	880

Table 3.2. Mean number of chicks per nest attempt. Numbers in parenthesis indicate the percentage of nest attempts successful. Success is defined as fledging 1 or more chicks per nest. Second nesting attempts not included.

					Summary since 1984			
Sub-region	Colony	2003-2004	2004-2005	2005-2006	Min	Mean	Max	% of Yrs Successful
Northwest	Sandy	0.86 (44%)	1.08 (74%)	1.33 (61%)	0.00	1.25	2.5	60%
Northeast	Tern	0.15 (8.7%)	0.1 (3%)	1.61 (63%)	0.00	0.79	2.2	35%
Central	EBA/Calusa	0 (0%)	.43 (20%)	1.71 (86%)	0.00	0.82	1.71	33%
Southeast	M. Butternut	0.14 (14%)	1.11 (67%)	.86 (36%)	0.14	0.97	2.09	40%

Table 3.3. Number of ROSP banded in Florida Bay Dec 2003-April 2004, and in Tampa Bay, April 2004. "Number of ROSP Resighted Alive" indicates the number of birds resighted after the age of 21+ days.

Estuary	Sub-region	Colonies where Roseate Spoonbills were Banded	Number of Nests Banded	Number of Chicks Banded	Number of ROSP Resighted Alive	Number of ROSP Resighted Dead	Number of ROSP Presumed Dead	Number of ROSP where Fate is Unknown
Florida Bay	Northwest	Sandy	19	39	18 (46%)	5 (13%)	1 (3%)	15 (38%)
		Frank	18	37	2 (5%)			35 (95%)
		Clive	1	2				2 (100%)
	Northeast	Tern	22	40	2 (5%)	7 (17.5%)	9 (22.5%)	22 (55%)
		N. Park	2	3	2 (67%)			1 (33%)
		Duck	3	6		4 (67%)	2 (33%)	
	Central	E. Bob Allen	1	2				2 (100%)
		Jimmie Channel	1	1				1 (100%)
		Calusa	5	11	2 (18%)	1 (9%)	4 (36%)	4 (36%)
	Southeast	M. Butternut	2	3	1 (33%)	2 (67%)		
		Stake	1	1				1 (100%)
		Crab	1	3			3 (100%)	
		East	4	5	1 (20%)	1 (20%)		3 (60%)
		Crane	2	3		1 (33%)	2 (67%)	
		E. Butternut	3	6	4 (67%)	1 (16%)	1 (16%)	
	Total		85	162	32 (20%)	22 (13.5%)	22 (13.5%)	86 (53%)

Tampa Bay	Alafia Bank	131	233	216 (93%)	2 (.6%)	15 (6.4%)

Table 3.4. Number of ROSP banded in Florida Bay Dec 2004-April 2005, and in Tampa Bay, April 2005. "Number of ROSP Resighted Alive" indicates the number of birds resighted after the age of 21+ days.

Estuary	Sub-region	Colonies where Roseate Spoonbills were Banded	Number of Nests Banded	Number of Chicks Banded	Number of ROSP Resighted Alive	Number of ROSP Resighted Dead	Number of ROSP where Fate is Unknown
Florida Bay	Northwest	Sandy	86	200	120 (60%)	11 (6%)	69 (34%)
		Frank	20	42	6 (14%)		36 (86%)
		Clive	2	3			3 (100%)
		Palm	11	26	10 (38%)		16 (62%)
	Northeast	Tern	17	32	11 (34%)	8 (25%)	13 (41%)
		N. Nest	1	2	1 (50%)		1 (50%)
	Central	E. Bob Allen	2	4	3 (75%)		1 (25%)
		Jimmie Channel	6	12	1 (8%)	4 (33%)	7 (58%)
		Calusa	5	11	1 (9%)	8 (73%)	2 (18%)
		S. Park	2	3	2 (67%)		1 (33%)
	Southeast	M. Butternut	4	9	1 (11%)	6 (67%)	2 (22%)
		Stake	1	2		2 (100%)	
		Pigeon	23	57	29 (51%)	2 (4%)	26 (45%)

		East	5	10	2 (20%)	5 (50%)	3 (30%)
		Crane	1	2			2 (100%)
		Florida Bay Total	186	415	187 (45%)	46 (11%)	182 (44%)
Tampa Bay		Alafia Bank	58	105	89 (85%)		16 (15%)

Table 3.5. Number of ROSP banded in Florida Bay Dec 2005-April 2006, and in Tampa Bay, April 2006. "Number of ROSP Resighted Alive" indicates the number of birds resighted after the age of 21+ days.

Estuary	Sub-region	Colonies where Roseate Spoonbills were Banded	Number of Nests Banded	Number of Chicks Banded	Number of ROSP Resighted Alive	Number of ROSP Resighted Dead	Number of ROSP where Fate is Unknown
Florida Bay	Northwest	Sandy	58	159	80 (50%)	28 (18%)	51 (32%)
	Northeast	Tern	22	58	14 (24%)	6 (10%)	38 (66%)
		S. Nest	8	17	10 (59%)		7 (41%)
		N. Nest	1	3	3 (100%)		
		N. Park	1	4	1 (25%)	2 (50%)	1 (25%)
		Deer	1	3	3 (100%)		
	Central	Calusa	9	19	18 (95%)	1 (5%)	
		Jimmie Channel	22	54	30 (56%)	1 (1%)	23 (43%)

	E. Bob Allen	1	1			1 (100%)
	S. Park	18	43	17 (40%)	3 (7%)	23 (53%)
Southeast	M. Butternut	9	24	6 (25%)	1 (4%)	17 (71%)
	Stake	3	6	2 (33%)	1 (17%)	3 (50%)
	Pigeon	13	34	14 (41%)		20 (59%)
	East	3	9	3 (33.3%)	4 (44.4%)	2 (22.2%)
	Crane	17	37	9 (24%)	13 (35%)	15 (41%)
	Bottle	1	1			1 (100%)
	Florida Bay Total	187	472	210 (44%)	60 (13%)	202 (43%)
Tampa Bay	Alafia Bank	97	230	196 (85%)	4 (2%)	30 (13%)
	Washburn Junior	11	34	29 (85%)		5 (15%)
	Tampa Bay Total	108	264	225 (85%)	4 (2%)	35 (13%)

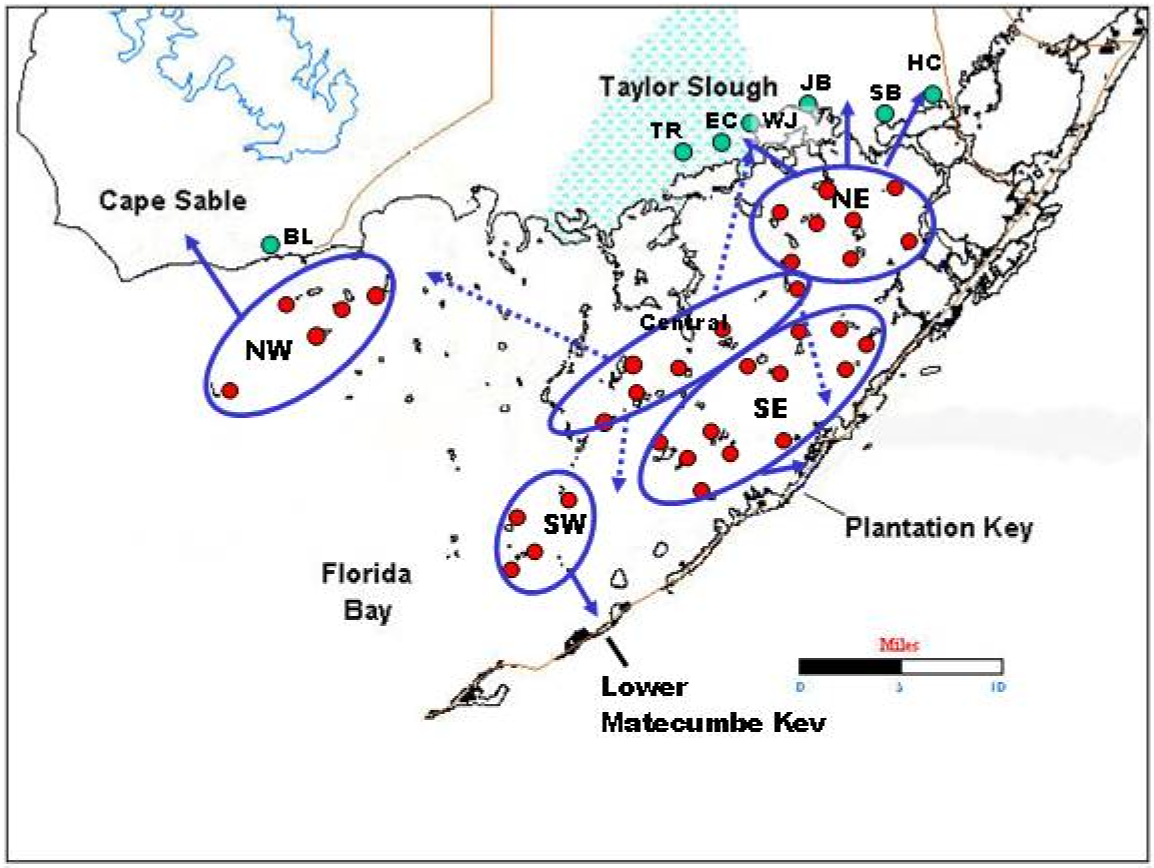

Figure 3.1. Map of Florida Bay Indicating spoonbill colony locations (red circles) and nesting regions (blue circles). Arrows indicate the primary foraging area for each region. The dashed lines from the central region are speculative. Approximate location of fish sampling sites are represented by green circles.