SOUTH FLORIDA WADING BIRD REPORT

Volume 14 | Mark I. Cook and Mac Kobza, Editors | November 2008

IN MEMORY

The contributors and editors of the South Florida Wading Bird Report dedicate this year's issue to the memory of Damion Marx, Phil Heidemann and Gareth Akerman, three young ecologists who tragically lost their lives on March 13, 2008 while conducting an aerial survey of wading birds around Lake Okeechobee.

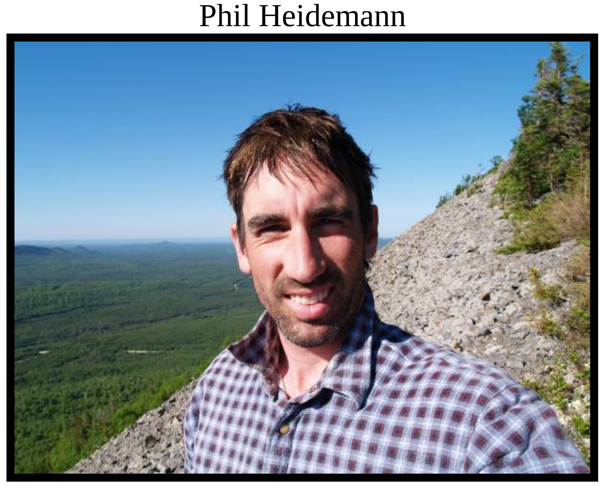
Damion, Phil and Gareth were research students and professionals in the lab of Dale Gawlik at Florida Atlantic University, Boca Raton. Damion was close to finishing his PhD dissertation on the influence of patch structure on wading bird foraging patterns, Phil was an M.S. candidate developing a landscape suitability index for Wood Stork and White Ibis in southwestern Florida, and Gareth was looking to gain additional experience in conservation biology after recently completing his Masters dissertation on the role of riparian buffers in forest bird conservation at Dalhousie University, Canada. There is no question that all had a sense of adventure, a desire to improve our world and fervor for understanding and protecting nature. All were devoted to advancing wading bird conservation and Everglades restoration. They risked and lost their lives in the backwaters of south Florida, doing what they loved and what they passionately believed would benefit the ecosystems of south Florida. They will be sorely missed by their colleagues, but neither they nor their important research will be forgotten.

Further words from their mentor and good friend, Dale Gawlik, can be found at the link below.

http://www.science.fau.edu/biology/gawliklab/memorial/memorial.html

Damion Marx

Phil Heidemann



Gareth Akerman

SYSTEM-WIDE SUMMARY

Water-year 2008 (May 2007 through Apr 2008) included the tail-end of an official two-year drought and started with below average stage and a delayed onset to the wet season. Annual rainfall was generally above average, particularly in the northern WCAs, but its timing was far from normal with limited precipitation during the wet season and multiple large rain events during the dry season. This resulted in below average stages and generally dry conditions at the onset of wading bird nesting, and a series of rainfall induced reversals during peak nesting.

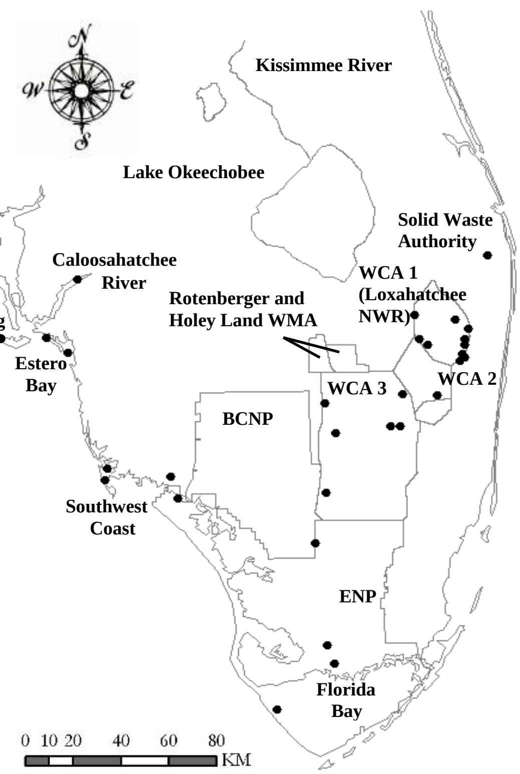
The estimated number of wading bird nests in South Florida in 2008 was 18,418. This is a 51% decrease relative to last year's season, 74% less than the 68,750 nests of 2002, which was the best nesting year on record in South Florida since the 1940s, and 59% less than the average of the last eight years. This year, counts from J. N. 'Ding' Darling National Wildlife Refuge Complex are included in the total after a survey hiatus of two years.

Systematic nest survey coverage was expanded in 2005 to include Lake Okeechobee and the recently restored section of the Kissimmee River floodplain. In 2008, we expand coverage further with the introduction of nest counts from Estero Bay Aquatic Preserve. For Lake Okeechobee, 2008 ranks as the worst nesting year on record with a peak of only 39 nests. This is a dramatic reduction on the 11,310 nests observed in 2006 and lower even than the poor nesting effort of 2007 when 774 nests were recorded. On the restored sections of the Kissimmee floodplain, the timing and magnitude of floodplain inundation and recession are not yet optimal for colony formation, and nesting has been very limited in recent decades. In 2008 only six nests were recorded on the floodplain. Implementation of the regulation schedule for the Headwaters Revitalization Project in 2010 will allow water managers to more closely mimic the historical stage and discharge characteristics of the river, presumably leading to suitable hydrologic conditions for wading bird nesting colonies. Estero Bay supported 206 wading bird nests in 2008. Note that the totals for these three regions are not included in the system-wide total.

All species of wading birds suffered significantly reduced nest numbers relative to the past ten years. For example, Wood Stork reproduction was very much reduced and this was the first time that nesting was not initiated at the historical Corkscrew colony for two consecutive years (see special section). White Ibis numbers were down 61% on last year and 64% lower than the past ten years. Roseate Spoonbill nest numbers were the lowest since records began in 1983.

Nesting effort in the Everglades is rarely distributed uniformly among regions. In 2008, WCA-1 supported the most nests (71%) followed by WCA-3 (23%), whereas ENP supported only 6%. This spatial distribution of nests continues the recent trend of an annual increase in the proportion of birds nesting in WCA-1 at the expense of nesting in WCA-3. ENP historically supported the largest number of nests in the system at the traditional estuarine "rookeries" downstream of Shark Slough. Nesting effort in the estuaries has increased gradually over recent years (e.g., 20% in 2006) but this year these regions supported only minimum nesting. CERP's goal is to increase the proportion of birds nesting in this estuarine ecotone. Another pattern over the past ten years has been for a large proportion of nests in South Florida to be concentrated in a single large colony (Alley North) located in northeast WCA-3A. For two consecutive breeding seasons Alley North and the adjacent marsh dried prior to breeding and nesting was not initiated at the colony.

Locations of wading bird colonies with ≥ 50 nests in South Florida, 2008.



Generally, nesting was not successful for most species. Many birds abandoned nests throughout the system after rain-induced water level reversals in March and April. In the few places that Wood Storks attempted to nest in the Everglades (Paurotis Pond and Cuthbert Lake) all nests failed following these rain events. However, the presence of large numbers of mature White Ibis

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nestling at Lox West colony in July suggested that late-nesting ibis in WCA-1 were reasonably successful.

Two of four species-groups, White Ibis and Great Egrets, met the numeric nesting targets proposed by the South Florida Ecosystem Restoration Task Force. Two other targets for the Everglades restoration are an increase in the number of nesting wading birds in the coastal Everglades and a shift in the timing of Wood Stork nesting to earlier in the breeding season (Ogden, 1994). The 2008 nesting year showed no improvement in the timing of Wood Stork nesting or a general shift of colony locations.

Although reproductive output was limited this year, Systematic Reconnaissance Flight surveys revealed that the Everglades was an important foraging area in WY2008. A total of 632,016 birds were counted in the WCAs and ENP between December 2007 and June 2008, which is 29% more than the five-year average. The temporal patterns of abundance in 2008 were remarkably similar to last year, with high numbers observed from December through March followed by a marked decline from April as water levels increased. On the restored sections of the Kissimmee River floodplain the mean number of birds per square kilometer rebounded after the post-restoration low of 2007, but this was less than a third of the density observed in 2006.

This year's poor reproductive effort and success were almost certainly due to two preceding years of drought and its affect on system-wide prey productivity. Low stages and short hydroperiods are not conducive to fish and crayfish production, and many areas in WY2007 and WY2008 were characterized by reduced dry-season prey densities (D Gawlik pers. com.) and nestling diets that contained high proportions of terrestrial prey (M Cook pers. obs.). WY2008 did receive higher than average annual precipitation, but much of this rain fell too late to benefit aquatic fauna and instead fell during the dry-season causing widespread water-level reversals and the dispersal of an already limited prey base. This appeared to result in wide-spread nesting failure for those birds that did attempt nesting. WCA-1 experienced less severe drought conditions relative to other parts of the Everglades, and this may account for the increased nesting effort in this area. It is unclear why numbers of foraging birds should increase during drought years but it may be due to a lack of suitable foraging conditions elsewhere in south Florida.

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HYDROLOGY 2008

The amount of rain in the Everglades Protection Area (EPA) for Water Year 2008 (WY08 May 1, 2007 through April 30, 2008) was greater than last year by as much as 10.6 inches, in WCA-1, or by as little as 4.6 inches, in WCA-3. Most of this added rainfall fell during the dry season, during wading bird nesting, making wading bird foraging conditions less than favorable. The rainfall and associated stage readings for WY2008 are shown in Table 1 below. Water Conservation Areas 1 and 2 saw a 7% increase in historic rainfall amounts and a 24% increase over WY07. On–the-other-hand, Water Conservation Areas 3 saw a 5% decrease in historic rainfall amounts and only a 10% increase over WY07. The Everglades National Park (ENP) saw a 10% increase in historic rainfall amounts and a 15% increase over WY07. It is interesting to note that after a year of severe drought, the maximum stage for WCA-1 in WY08 came close to the historic maximum stage. This kind of hydrology may account for the resilience of the wading bird populations that were clustering in this region in WY08.

In WY08 most of the rain fell during the wet season months of June and September and then again during the dry season months of February, March and April. In ENP, rain in June was 13.28 inches and in September was 10.99 inches creating a pulse-like hydrograph (see Figure 1). In March to April monthly rainfall in the Park averaged about 2.75 inches. In the WCA's, rain in June was about 8.5 inches and in September was about 9.0 inches. In the WCA's there were only two months out of the year that rainfall dropped below 1 inch for the month. In the Park rainfall was below 1 inch from November through January. As shown in the following hydrographs, what might be expected from an above average **annual** rainfall following a year of drought (i.e., a return to good foraging conditions for wading birds) did not come to fruition in water year 2008.

The following hydropattern figures highlight the average stage changes in each of the WCAs for the last two years in relation to the recent historic averages, flooding tolerances for tree islands, drought tolerances for wetland peat, and recession rates and depths that support both nesting initiation and foraging success by wading birds. These indices were used by the SFWMD to facilitate weekly operational discussions and decisions. Tree island flooding tolerances are considered exceeded when depths on the islands are greater than 1 foot for more than 120 days (Wu and Sklar, 2002). Drought tolerances are considered exceeded when water levels are greater than 1 foot below ground for more than 30 days, i.e., the criteria for Minimum Flows and Levels in the Everglades (SFWMD, 2003). Figure 1 shows the ground elevations in the WCAs as being essentially the same as the threshold for peat conservation. The wading bird nesting period is divided into three simple categories (red, yellow, and green) based upon foraging conditions in the Everglades (Gawlik et al. 2004). A red label indicates poor conditions due to recession rates that are too fast (greater than 0.6 foot per week) or too slow (less than 0.04 foot for more than two weeks). A red label is also given when the average depth change for the week is positive rather than negative. A yellow label indicates fair conditions due to a slow recession rate of 0.04 foot for a week or a rapid recession between 0.17 foot and 0.6

foot per week. A green/good label is assigned when water depth decreased between 0.05 foot and 0.16 foot per week. Although these labels are not indicative of an appropriate depth for foraging, they have been useful during high water conditions to highlight recession rates that can lead to good foraging depths toward the end of the dry season (i.e., April and May).

WCA-1

The 2008 Water-Year for WCA-1 started at very low water conditions, after a nine-month period of below average water levels. Water depths rose from a low in June of only a few inches to depths of 2.5 ft in a matter of only three months and remained above average throughout the rest of the water year (Figure 1A). The upper flooding tolerances for tree islands were reached very briefly in October 2007. Recession rates were poor for most of the 2008 dry season and stage trends were opposite from the steady declines observed during the previous dry season. Last year, water depths became optimum for foraging in central and southern WCA-1 during April and May. This year, optimum depths were not reached until June. However, June was probably an excellent foraging month because April and May of this year had good recession rates creating the perfect "set-up" for foraging when the right depths are reached. Unfortunately, by July the optimum depths were starting to be exceeded. Dry season foraging by wading birds in WCA-1 probably slowed significantly in mid-July. For the third year in a row, WCA-1 had the longest duration of good nesting and foraging periods of any region in the EPA.

WCA-2A and 2B

For the last three years in WCA-2A, the stage levels during the wet season have exceeded the upper flood tolerance for tree islands for a period of 1-2 months, which is not enough to cause any tree island damage (Wu and Sklar, 2002). The few islands that remain in this region are not likely to be impacted due to their NW location and their relative elevations. However, future efforts to restore WCA-2A islands will require a closer examination (i.e., frequency analysis) of these kinds of exceedences. In WCA-2A, the WY06 and WY07 dry seasons were very similar. Both dry seasons had very good recession rates, and both times the region completely dried out. However, in WY06, WCA-2A exhibited excellent foraging conditions and many flocks of wading birds were observed. In WY07, hydroperiod was very short and stage was below average for most of the year and as a result, reports of large or many flocks were greatly reduced. This year (WY08) there was some evidence of a large return of the WCA-2A prey-base for wading birds because the hydroperiod was lengthened and because foraging was limited to the month of May due to poor recession rates for most of the dry season **(**Figure 1B**)**.

WCA-2B has always been utilized by wading birds during droughts because it tends to stay deeper for longer periods than the rest of the EPA. This was particularly true in WY06 when dry season water levels went below ground in WCA-2A and the wading birds moved to WCA-2B. Last year, the drought was so severe that even 2B became too dry to support any foraging from May to July. It was unique to see depths drop some two feet below ground in this region last year. This year was a completely different story. July rainfall caused water depths to increase rapidly in 2B and a maximum depth of 4 ft was reached in November. Just when wading birds needed good recession rates (March, April and May), water levels increased and never dropped low enough to support foraging (Figure 1C). Relief from foraging this year is expected to increase the prey-base in this region and possibly support large nesting flocks next year.

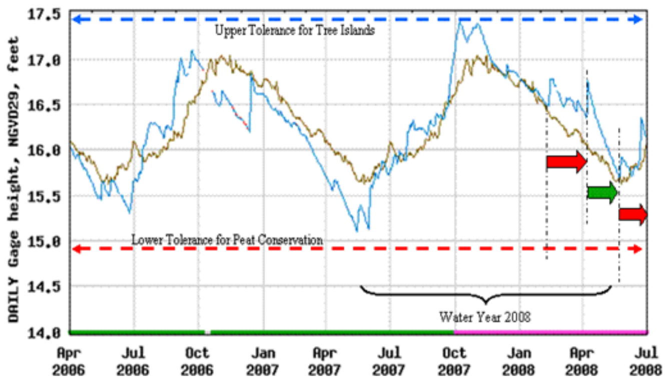
Table 1. Average, minimum, and maximum stage (ft NGVD) and total annual rainfall (inches) for Water Year 2008 in comparison to historic stage and rainfall.[1] Subtract elevation from stage to calculate average depths.

Area	WY2008 Rainfall	Historic Rainfall	WY2008 Stage Mean (min; max)	Historic Stage Mean (min; max)	Elevation
WCA-1	55.54	51.96	16.20 (13.57; 17.54)	15.60 (10.0; 18.16)	15.1
WCA-2	55.54	51.96	12.26 (10.29; 13.98)	12.55 (9.33; 15.64)	11.2
WCA-3	48.89	51.37	9.3 (5.89; 10.16)	9.53 (4.78; 12.79)	8.2
ENP	60.92	55.22	5.94 (5.39; 6.33)	5.98 (2.01; 8.08)	5.1

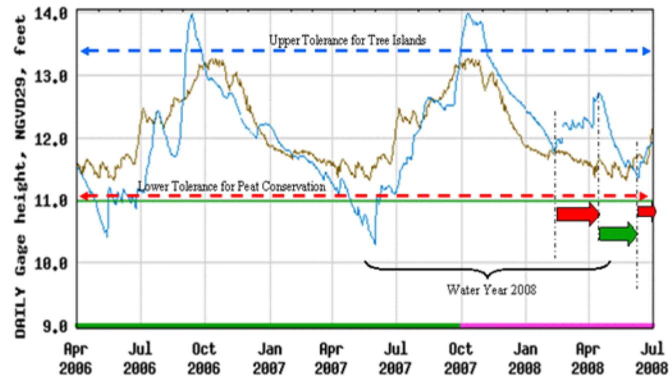
[1] See Chapter 2 of the 2009 South Florida Environmental Report for a more detailed description of rain, stage, inflows, outflows, and historic databases.

Figure 1. Hydrology in the WCAs and ENP in relation to recent average water depths (A: 10 yr ave, B: 13 yr ave, C: 13 yr ave, D: 14 yr ave, E: 14 yr ave, F: 13 yr ave, G: 25 yr ave) and indices for tree islands, peat conservation, and wading bird foraging depths.

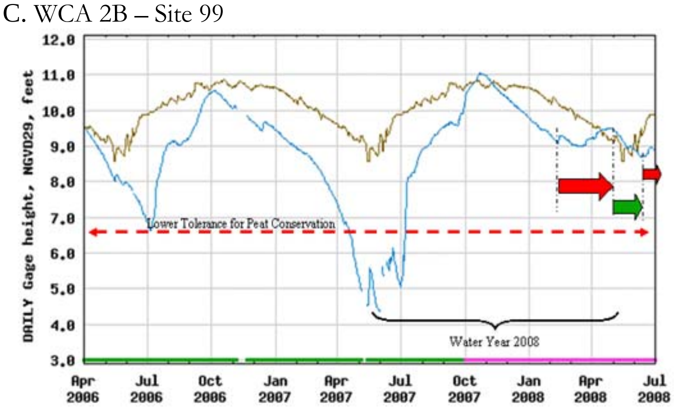
A. WCA 1 – Site 9



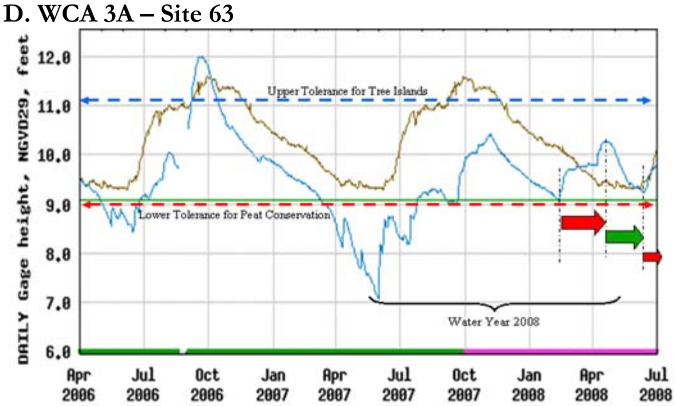
B. WCA 2A – Site 17



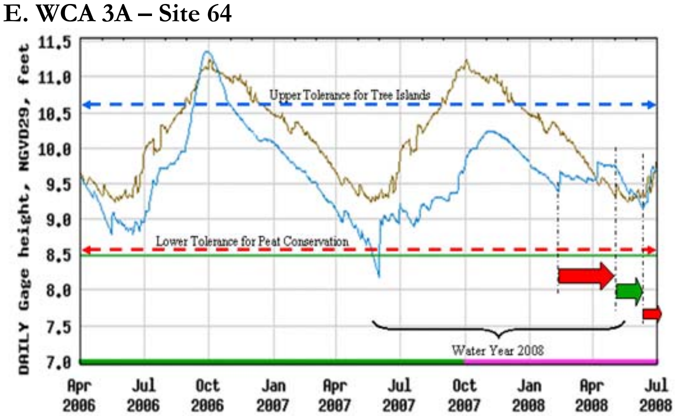
C. WCA 2B – Site 99



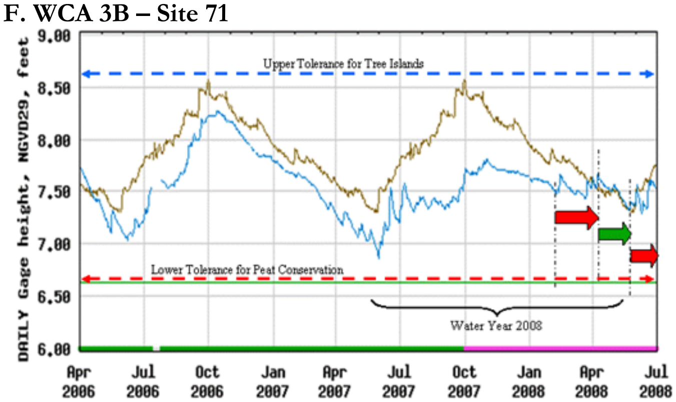
D. WCA 3A – Site 63



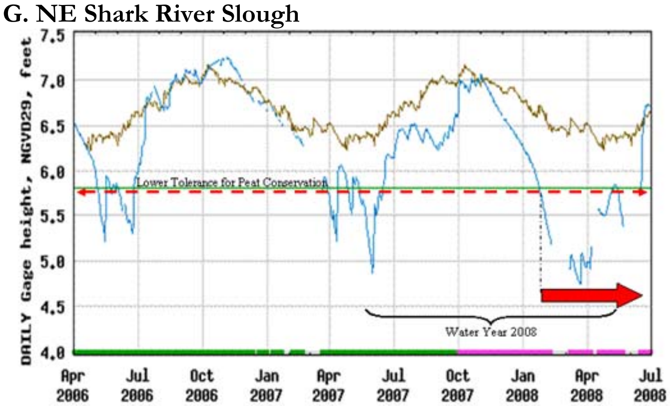
E. WCA 3A – Site 64

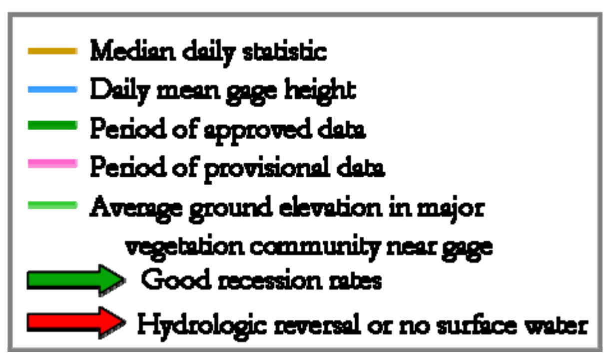


F. WCA 3B – Site 71



G. NE Shark River Slough





WCA-3A

The hydrology in the northeastern region of WCA-3A (Gage-63) in WY07 was very different from that in WCA-1 and WCA-2A (Figure 1D). In this part of the Everglades, the WY07 drought extended well into WY08. (Note: More than one foot below ground violates the guidance for Minimum Flows and Levels.) It is very unlikely that such a reduced hydroperiod could be capable of rejuvenating the prey-base for the large wading bird rookery (Alley North) where annual nesting during the past decade has frequently exceeded 20,000 nests. Water depths barely went over 1 ft for a few weeks. When nesting was expected to begin in March, water levels increased rather than decreased as would be needed to concentrate the prey-base into sloughs and pools. This region dried out to a much greater degree than it did last year, which dried out to a much greater degree than the year before, and the combination of a late wet season and extended dry season created an inhospitable environment for wading birds, especially those that frequent the popular Alley North Rookery. During the dry seasons of WY06 and WY07, the birds were lucky that their rookery did not burn. This was the second year in a row the birds were smart enough not to use Alley North as a nesting location.

The hydrologic pattern in central WCA-3A (Gage-64) in WY08 did not suffer the drought as much as the northeast WCA-3A (Figure 1E). Although there was no MFL violation to speak of, there was instead a greatly reduced wet-season stage. Water depths did not go above 1 ft until October and never went over 2 ft the entire water year. What should have been a great wading bird foraging environment starting in March was instead disrupted by increasing water levels rather than decreasing water levels for almost the entire nesting (dry) season. Last year the shallow depths and short duration of the wet season was probably sufficient to cause widespread depletion of wading bird prey species. This year, the lack of foraging and the longer hydroperiod may well translate into a banner prey-base for next year (WY09).

WCA-3B

In WY06, the water depths in WCA-3B did not go below 0.5 foot (optimum foraging depth) until May 2006, after most nesting behaviors had ceased. In WY07, short but numerous reversals made this region marginal for foraging. This year water depths remained almost constant all year round, and recession rates were not long-lived enough (Figure 1F) to function as a prey-concentrating mechanism (assuming that depths were adequate for prey recruitment). So, for three years in a row, this region's hydrology has not supported wading bird nesting or foraging.

Northeast Shark River Slough

The uniqueness of the hydrology and drought in the Everglades during WY07 and WY08 is captured by the Northeast Shark River Slough (NESRS) hydrograph (Figure 1G). For three years in a row this region of Everglades National Park experienced significant violations of the MFL standard, and most of those violations occurred this year. Water levels in this part of the system began dropping in December, and never had any water to support wading birds during the nesting season. It is no surprise, looking at this hydrograph, that large areas of this region (i.e., the Mustang Corner) experienced vegetation and peat fires this past year. It is unlikely that the prey-base is large enough for sufficient recruitment next year and foraging is not expected to be good again in this region until appropriate hydrologic conditions return.

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REGIONAL NESTING REPORTS

WATER CONSERVATION AREAS 2 AND 3, AND A.R.M. LOXAHATCHEE NATIONAL WILDLIFE REFUGE

In 2008, the University of Florida team monitored nesting in WCAs 2 and 3 and Loxahatchee for nesting by long-legged wading birds. We concentrated effort on documenting numbers of Great Egrets, White Ibises, Snowy Egrets and Wood Storks, and continued to refine our methods for estimating numbers of birds in very large colonies. We also made a partial assessment of the use of unmanned aerial systems (small unmanned aircraft) specifically for use in wading bird surveys of various kinds.

Methods

We performed two types of systematic surveys in 2008: aerial and ground surveys. 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 February and June we performed systematic aerial surveys for colonies, with observers on both sides of a Cessna 172, 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. We took aerial photos of larger colonies from directly overhead and from multiple angles, and made detailed counts of the apparently nesting birds showing in these slides via projection. The reported numbers of nest starts are usually "peak" counts, in which the highest count for the season is used as the estimate of nests. The only exceptions to this rule were colonies in which clearly different cohorts were noted in the same colony, in which case the peak counts of the cohorts was summed. In some cases we also modified total aerial counts with information from ground checks. In addition, we used some estimates from the South Florida Water Management District, which performs surveys of the larger colonies via helicopter in the first week of every month. These were particularly valuable for times when the colonies were changing quickly (new startups and abandonments) that might have been otherwise missed by our mid-month systematic surveys.

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. These were designed to document small colonies or those of dark-colored species that are difficult to detect from aerial surveys. Since 2004, 100% coverage ground surveys were discontinued due to a change in MAP guidelines for monitoring. However, we did perform some systematic ground surveys in WCA 3 that allowed 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 that might be sustainable. In the case of all ground surveys, all tree islands were approached closely enough to flush nesting birds, and nests were either counted directly, or estimated from flushed birds.

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.

Results

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 15,204 nests of wading birds (Cattle Egrets, Anhingas and cormorants excluded) were initiated between February and July of 2008 (Tables 1 & 2). Note that this figure does not include birds nesting at the Tamiami West colony, which we also monitored intensively in ENP.

ABBREVIATIONS

Species: Great Egret (GREG), Snowy Egret (SNEG), Reddish Egret (REEG), Cattle Egret (CAEG), Great Blue Heron (GBHE), Great White Heron (GWHE), Little Blue Heron (LBHE), Tricolored Heron (TRHE), Green Heron (GRHE), Black-crowned Night-Heron (BCNH), Yellow-crowned Night-Heron (YCNH), Roseate Spoonbill (ROSP), Wood Stork (WOST), White Ibis (WHIB), Glossy Ibis (GLIB), Anhinga (ANHI), Double-crested Cormorant (DCCO), Brown Pelican (BRPE), Osprey (OSPR), Bald Eagle (BAEA), small dark herons (SML DRK), and small white herons (SML WHT).

Regions, Agencies, and Miscellaneous: Water Conservation Area (WCA), Everglades National Park (ENP), Wildlife Management Area (WMA), A.R.M. Loxahatchee National Wildlife Refuge (LNWR), Lake Worth Drainage District (LWDD), Solid Waste Authority (SWA), South Florida Water Management District (SFWMD), U.S. Army Corp of Engineers (USACOE), Systematic Reconnaissance Flights (SRF), Comprehensive Everglades Restoration Plan (CERP), and Natural Systems Model (NSM).

Table 1. Numbers of nests of wading birds found in A.R.M. Loxahatchee National Wildlife Refuge during systematic surveys, Jan - June 2008

Latitude	Longitude	WCA	Colony	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	SmWt	LgDk	SmDk	TRHE	GLIB	BCNH	Total
26.55010	-80.44270	1	LOXW	233	3561		16	567									4377
26.53280	-80.27620	1	NEWCOL4	229			2		1		2553						2785
26.43822	-80.39053	1	LOX99	221	892						140	3					1256
26.49650	-80.22288	1	LOXRAMP		180					680							860
26.43510	-80.23720	1	LOX70		800												800
26.37217	-80.26020	1	LOX73	30	513				1		6						550
26.45857	-80.24032	1	NEWCOL2	294							32						326
26.39895	-80.24992	1	VENUS	114	36						27		2				179
26.45913	-80.42335	1	VULCAN							156							156
26.59810	-80.28547	1	ZULU								23						23
26.50985	-80.32375	1	WATS							17							17
26.55353	-80.26452	1	YAM	8				9									17
26.57228	-80.27217	1	YMIR	10					5				2				17
26.52470	-80.43570	1	WAFFLE								16						16
26.45010	-80.26287	1	VOLTA	12													12
26.46838	-80.37228	1	WELT							11							11
26.37197	-80.31035	1	UTU	8													8
26.37210	-80.29265	1	UZANA	8													8
26.39393	-80.33868	1	UZUME	8													8
26.55737	-80.25987	1	YEW	6													6
26.39220	-80.31227	1	UZED	4													4
Total nests for Colonies > 50				1121	5982		18	567	2	836	2758	3	2				11289
Total nests for Colonies < 50				64				9	5	28	39		2				147
Grand total				1185	5982		18	576	7	864	2797	3	4				11436

Table 2. Numbers of nests of wading birds found in WCAs 2 and 3 during systematic surveys, Jan - June 2008

Latitude	Longitude	WCA	Colony	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	Sml.	Lrg	Sml.	TRHE	GLIB	BCNH	Total
26.12428	-80.54148	3	6THBRDG	76	1000		1	250	3		250						1580
26.21360	-80.81470	3	ROTOR	108				3	2	297	37						447
25.86842	-80.80663	3	ENKI							172	8			102			282
26.12408	-80.50438	3	CYPRESS CITY	245			9		15								269
26.38775	-80.23857	3	UNTEW		243												243
26.09846	-80.76870	3	MELBA					3		47				58			108
26.24600	-80.49300	3	SPOONIE				40				11						51
26.20132	-80.52873	3	ALLEY NORTH	43					1								44
25.86541	-80.80342	3	ECHO							37				4			41
25.82065	-80.67693	3	YONTEAU	27							7						34
25.77353	-80.83722	3	HIDDEN	30													30
25.93890	-80.53030	3	HERBIE	28													28
26.20979	-80.66408	3	RAMA					1		25							26
25.83184	-80.53257	3	DANA	22													22
26.10715	-80.49802	3	NANSE	20													20
26.04602	-80.62586	3	BIG MEL	14					1				1				16
26.03640	-80.78980	3	HILBRA	13					1								14
25.82025	-80.50132	3	CYDER	12													12
26.01230	-80.63233	3	JOULE	10					2								12
26.00012	-80.59513	3	JANUS	8					3								11
25.76900	-80.67835	3	BRAHMA	10													10
25.81939	-80.61354	3	CINDER	10													10
25.91565	-80.63022	3	VACATION	6					4								10
25.94280	-80.66680	3	HANDEL	9													9
25.96052	-80.57207	3	HORUS	8													8
25.92347	-80.51858	3	GANGA	7													7
25.92390	-80.54260	3	GRANT	7													7
25.84863	-80.51932	3	DIONYSUS	5													5
25.84723	-80.53150	3	DAMKINA	4													4
25.95902	-80.47898	3	HESTIA	3													3
25.83770	-80.81890	3	CANDER						2								2
26.01360	-80.45632	3	JUNO						2								2
25.91450	-80.47640	3	GARGOYLE						1								1
26.01557	-80.56272	3	JUPITER	1													1
26.24335	-80.35072	2	SHIVA	144	7			26	1	12				1			191
26.23782	-80.31280	2	RHEA	19					3								22
Ground surveys		3		29					23	11				4		119	186
Total nests for Colonies > 50				573	1250		50	282	21	528	306			161			3171
Total nests for Colonies < 50				316				1	20	62	7		1	4			411
Grand total				918	1250	0	50	283	64	601	313	0	1	169	0	119	3768

Table 3. Annual numbers of nests of aquatic birds found in A.R.M. Loxahatchee National Wildlife Refuge and WCAs 2 and 3 from 2005 through 2008

WCA	Year	GREG	WHIB	WOST	ROSP	SNEG	GBHE	LBHE	Unkwn	SmDk	TRHE	GLIB	BCNH	CAEG	Total
LNWR	2005	1361	2994			238		599							5192
	2006	1800	5194			3745	3				50	50	30		10872
	2007	1792	8271				13	730	66		1			4797	15670
	2008	1185	2421		18	9	10	864	6925	4					11436
WCAs 2&3	2005	2209	13004	20	11	2253	201	634	1		388	75	220		19016
	2006	5697	15698	190	40	4540	328	1212	28		561	192	289		28775
	2007	2141	10932		39	247	467	284	1700		142		409		16361
	2008	918	760		50	36	64	601	516	1	169		119		3768
Total for all WCAs	2005	3570	15998	20	11	2491	201	1233	1		388	75	220		24208
	2006	7497	20892	190	40	8285	331	1212	28		611	242	319		39647
	2007	3933	19203		39	247	480	1014	1766		143		409	4797	32031
	2008	2103	3181		68	45	74	1465	7441	5	169		119		15204

The size of the nesting aggregation in 2008 in the WCAs and LNWR combined was approximately 44% of the average of similar counts during the past five years, 47% of the average of the past ten years, and 25% of the banner year of 2002. Numbers of Great Egret nests were only 33% the average of the last five years, and 34% of the average of the last ten. In 2008, Wood Stork nests were very much reduced, with no pairs attempting to nest in the WCAs. White Ibis nests were 37% of the average of the last five and 40% the average of the last ten years. Compared with the banner year of 2002, only 23% of the ibis pairs nested in 2007. Approximately 860 Snowy Egrets attempted nesting, which was only 27% of the previous five years average and 24% of the last ten. Our estimates of ANHI numbers were poor this season. The delayed wading bird nesting meant that virtually no internal colony visits were conducted until well after peak ANHI activity.

Generally, nesting was not successful for any species, with the possible exception of ibises in Loxahatchee. Large abandonment events were seen throughout the system with the water level reversals that began in March and continued through April. We followed the fates of marked nests in three colonies in WCA 3: Vacation (N25 54.939 W80 37.813), Cypress City, and 6th Bridge. For all three islands, the nests initiated in March (mostly GREG) showed extremely high failure rates—90% for both Vacation (N = 10) and Cypress City (N = 21) based on marked nests and similar levels for 6th Bridge based on aerial photos. A subsequent nesting effort beginning mid-May/early-June on 6th Bridge revealed slightly better results (~50-75% failure), although the field season ended before the fates of many nests could be confirmed. In the places that Wood Storks did show evidence of nest attempts (Tamiami West, Paurotis Pond), all nests failed.

The difference in numbers of nests and nest success between Loxahatchee and WCA 3 this year was dramatic. Generally the largest colony in the system is at Alley North in WCA 3. This colony did not really form this year and contained no ibis nests. Loxahatchee contributed 76% of the total birds nesting in the WCAs, 82% of the ibises, and 57% of Great Egrets. This is highly disproportionate to its area and represents a departure with the past pattern. It seems likely that the more stable water conditions in Loxahatchee both over the last couple of years and over the course of the 2008 nesting season have contributed in some important way to the attractiveness of nesting. This result certainly suggests more detailed analysis.

In recent reports we did not differentiate total nest counts according to conservation area. Segregated totals for LNWR and WCA's 2 & 3 from 2005 – 2008 can be found in Table 3.

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EVERGLADES NATIONAL PARK

Mainland Areas February – August 2008

Methods

Aerial colony surveys of ENP were conducted monthly (February through August) by one observer from a Cessna 182 fixed-wing aircraft (~15 hours). Known colony sites were checked during each survey on 8 and 20 February, 3 and 17 March, 14 April, 20 May, 4 June, 1 and 16 July, and 1 August. (Note: not all colonies were surveyed on each date and some were checked while flying other wildlife project flights.) We also conducted two systematic colony surveys of the grassland regions within Shark and Taylor Sloughs where transient colonies often form (usually Great Egrets) on 23 and 25 April. Systematic surveys comprised 20 east-west oriented transects spaced 1.6 nautical miles apart (see Figure 1) using two observers from each side of a Cessna 182 (~12 hours). Flight altitude was 800 feet AGL.

Results

We observed comparatively little nesting activity within the mainland colonies of ENP this season (950 nests, Table 1). Compared to 2007, nest number estimates for all species combined were down by 71%. Breaking this down by species, Wood Stork nest numbers were down by 57%, Great Egret by 84%, White Ibis by 62% and Snowy Egret by 32%.

Only seven colonies were active and only two - Paurotis Pond and Alligator Bay - appeared to successfully fledge young. White Ibis were the most numerous of species nesting at both colonies. Great Egrets, Tricolored Herons and Little Blue Herons fledged young quite late in the nesting season at both colonies. Young egret and ibis branchlings could be seen from the airplane begging for food and later flying around the colonies. From photos taken during flights, young Tricolored Herons (both colonies) and Little Blue Herons (Paurotis Pond) were seen standing in trees. Roseate Spoonbill fledglings were seen at Paurotis Pond in February (see Lorenz et al. this issue for details).

We did not find any new colonies while flying systematic surveys over Shark and Taylor Sloughs. However we plan to continue these flights next season and anticipate that new colonies will be found when conditions are more favorable for nesting. In addition to systematic surveys, we also plan to conduct earlier checks for Roseate Spoonbill nesting activity (starting in October) at colonies where spoonbills have nested in recent years (i.e., Paurotis Pond and headwaters colonies.)

Wood stork nesting was unsuccessful this year in ENP. They attempted to nest only at Paurotis Pond and Cuthbert Lake, while the traditional nesting colonies of Tamiami West and Rodgers River had no stork activity. At Paurotis Pond, Wood Storks had a few nest starts when checked on 20 February. On 3 March there were 70 nests. On 17 March 40-50 of 125 visible nests had incubating adults and most of the remainder had adults standing at nests. Cuthbert Lake had very little Wood Stork activity. The few storks that gathered were not observed until 17 March. On that date approximately 20 pairs had visible nest starts. Unfortunately, Wood Storks at both Paurotis and Cuthbert abandoned all nests after several significant rain events in April.

Great Egrets nested at both Rookery Branch and East River colonies but abandoned in April. A few Roseate Spoonbills were seen at the Broad River colony site but we are not sure if they nested.

The drastically reduced nesting activity observed this year was most likely a result of the severe drought conditions that prevailed throughout the area. Foraging areas around most colony sites were dry until April. After several significant rain events in April, the conditions went from nearly completely dry to mostly flooded.

Beginning 1 July, the Rodgers River Island colony site was active with approximately 30 nesting Great Egrets. Fewer birds were seen nesting on the island when checked on 1 August. All other colony sites were empty.

Frank Key (Florida Bay) January - May 2008

Aerial surveys of Frank Key in Florida Bay were conducted on 8 February, 19 March, 18 April, 20 May and 4 June by one observer when conducting other ENP wildlife survey flights. Birds initiated nesting within the main egret and pelican colony sometime after 8 February. On 19 March, 75 Great Egrets and 25 Brown Pelicans were observed incubating on nests. On 18 April, the number of active Great Egret nests had declined to 40, however small young were seen on remaining nests. Pelican nests had increased to 60 and Double-crested Cormorants were also observed nesting among the egrets and pelicans. By May all egrets had abandoned their nests, however approximately 30 pelican nests were still active with half-grown young in the nests. White Ibis and Snowy Egrets were not seen in the colony this year.

Several pairs of Great White Herons (n = 4) nested successfully on Frank Key but were not located within the main egret and pelican nesting colony.

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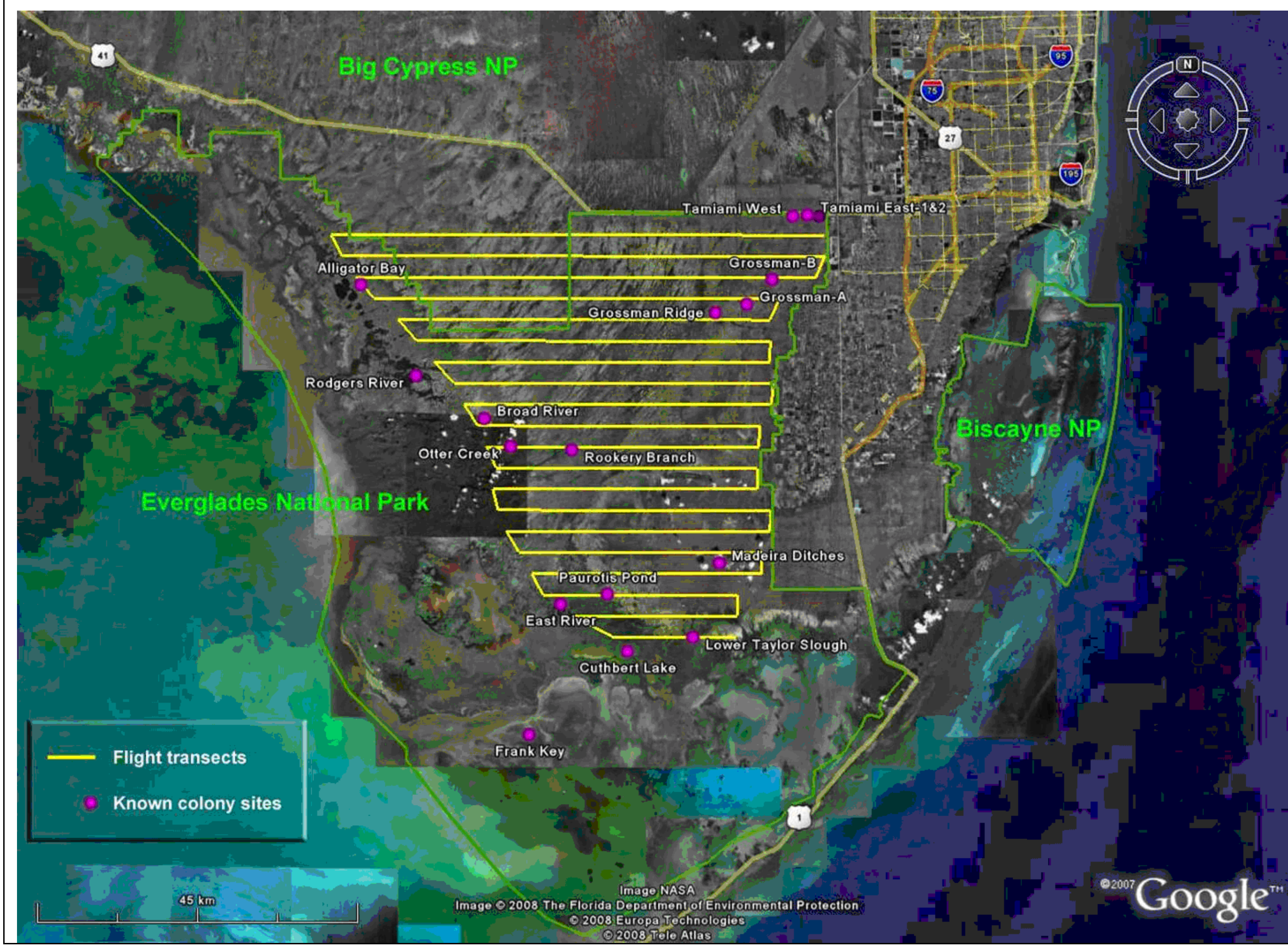
Table 1. Peak numbers of wading bird nests found in Everglades National Park colonies from 8 February through 1 August, 2008.

Mainland colonies only Colony name	Latitude WGS84	Longitude WGS84	GREG	WOST	WHIB	SNEG	CAEG	ROSP	TRHE	LBHE	BCNH	TOTAL
Alligator Bay	25 40.259	-81 08.828	50		300	50			+	+		400
Broad River	25 30.176	-80 58.464						+				+
Cuthbert Lake	25 12.560	-80 46.500	30	20*								30
East River Rookery	25 16.116	-80 52.071	5*									0
Paurotis Pond	25 16.890	-80 48.180	50	125*	250	+		+	+	+		300
Rodgers River Bay Island	25 33.400	-81 04.190	30									30
Rookery Branch	25 27.814	-80 51.153	40*									0
Total			205	145	550	50		+	+	+		950

+ Indicates species present and nesting, but unable to determine numbers
* Indicates nesting activity but abandoned nests

Figure 1. Systematic survey transects and known colony sites within Everglades National Park.



WOOD STORK NESTING AT CORKSCREW SWAMP SANCTUARY

Location: N26° 22.5024 W081° 36.9859

Methods
Corkscrew Sanctuary Staff conducted aerial surveys to known colony sites in Collier, Hendry and Lee County periodically from early November through May to monitor the Wood Stork nesting effort. No nesting effort was observed at Corkscrew Swamp Sanctuary at anytime throughout the nesting season.

Results
Wood storks arrived in Collier County in early October, occasionally visible foraging in roadside ditches. No nesting was initiated at the sanctuary for the second year in a row. Wood storks were observed at the Sanctuary foraging at the lettuce lakes in early March which were dry by the first of April. No other wading birds were observed nesting at Corkscrew throughout the survey period.

Hydrology
Water levels at the Corkscrew staff gage peaked just under 27" in late-September. This is more than 10" below the average wet-season high. Rainfall totals recorded at the Corkscrew visitor center were 27.75" from June 1st through September 30th, which is nearly 10" below the rainy season average for that period. This drought continued through the traditional nesting season in Southwest Florida. By March 15th water levels at the Lettuce Lake Steven's gage were at 5.04" which is more than 20" below average.

Other wood stork colonies in SW Florida

Numerous aerial surveys of other known wood stork colony locations in Collier, Lee and Hendry Counties were conducted from November 2007 through May 2008. The Lenore Island colony on the Caloosahatchee River was the only active nesting location found this season. Lenore Island is a mangrove island 2 miles down stream of the I-75 bridge on the Caloosahatchee river.

Methods
A fixed wing aircraft was flown at 1000' over nesting sites. When nesting efforts were identified; digital photographs were taken from 1000' and 500'. An 8.2 megapixel Canon EOS 30D body was used in combination with a 70-300mm lens for close-ups and an 18-55mm wide angle lens for landscape images. The close-up lens was equipped with an image stabilizer. Digital photos of the aerial survey for colony were examined and identifiable nested were digitally marked and recorded.

Results
Wood Storks: Lenore Island was the only productive wood stork nesting site this season. It was surveyed 9 times and photographed on 5 occasions from January through May of 2008. The peak wood stork nesting effort was recorded on March 28th, where 45 nests were positively identified, another six points on the island could have been wood stork nests, but the images were inconclusive. All of these nests are believed to have been in the early stages of incubation. The pronounced drought is believed to be the catalyst behind the depressed nesting numbers. Considerable nest abandonment occurred in April and May and the total nesting effort at Lenore Island produced an estimated 10 successful nests with a total of 12 wood stork fledglings. The productivity for this colony comes to 0.27 chicks per nest attempt.

Other waders: Forty great egrets were documented nesting from images captured on March 28th. Many of these appeared to be incubating. The May 29th survey revealed 37 great egret nests, many of which were new initiations as eggs were visible. The fate of these nests is unclear. At least 13 great blue herons nested on Lenore Island, along with two snowy egrets, one black-crowned night heron and one yellow-crowned night heron. Anhingas, double-crested cormorants, and brown pelicans were also nesting on the island. Estimates of colony nesting effort and productivity can be found below in Table 1.

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Table 1. Wading bird nesting effort recorded in Southwest Florida.

Latitude	Longitude	Colony	WOST			GBHE	GREG	SML WT	SML DRK	Total
			nests	successful	fledged					
26 22.502	-81 36.985	Corkscrew	0			na	na	na	na	0
26 41.332	-81 49.809	Lenore Island (Caloosahatchee West)	45	10	12	13	40	2	5	105
26 41.795	-81 47.697	Caloosahatchee East	0			0		0	0	0
26 22.223	-81 16.363	Collier/Hendry Line	0			0	0	0	0	0

SOLID WASTE AUTHORITY OF PALM BEACH COUNTY ROOKERY

Methods

Typically, Breeding Bird Censuses (BBCs) are conducted from February – July in the SWA Roost by two observers every 8-10 weeks, representing approximately 12 man-hours. During the BBC, all islands from three abandoned shell pits are systematically surveyed from a small boat, and the identified bird species and nest numbers are recorded. Surveys are conducted during the morning hours so as to minimize any burden caused by the presence of observers. However, this year's severe drought restricted boat access into the colony. The peak nest numbers are a compilation of early season boat counts and visual counts from the observation towers.

Location & Study Area

The SWA roost is located on spoil islands in abandoned shell pits that were mined in the early 1960's in Palm Beach County, Florida (Lat. 26°46'41"N: Long. 80°08'32"W NAD27). The spoil islands consist of overburden material and range from 5 to 367 m in length, with an average width of 5 m. Islands are separated by 5-6.5 m with vegetation touching among close islands. The borrow pits are flooded with fresh water to a depth of 3 m. Dominant vegetation is Brazilian pepper (*Schinus terebinthifolius*), Australian pine (*Casurina spp.*), and Melaleuca (*Melaleuca quinquenervia*), all non-native species. Local features influencing the roost include: 1) the North County Resource Recovery Facility and landfill and 2) the City of West Palm Beach's Grassy Waters (=Water Catchment Area), a 44 km² remnant of the Loxahatchee Slough.

Results

This report presents preliminary data for the 2008 breeding season. Typically, nesting activities have been observed at this colony through September, and these surveys being reported are only through the end of July. Only the peak nest numbers are being reported for each of the bird species (Table 1).

The estimated peak number of wading bird nests for the SWA Colony is 2042 which represents about a 74.9 % increase from the previous 2007 season. Despite the drought, there were nests of the following bird species: Great Egrets, Snowy Egrets, Cattle Egrets, Wood Storks, White Ibis, Little Blue Herons, Tricolor Herons, and Anhinga. The Wood Stork nest numbers were slightly higher than last year. It should also be mentioned that there was at least 5-7 Roseate Spoonbill nests with a few fledglings observed from the boat.

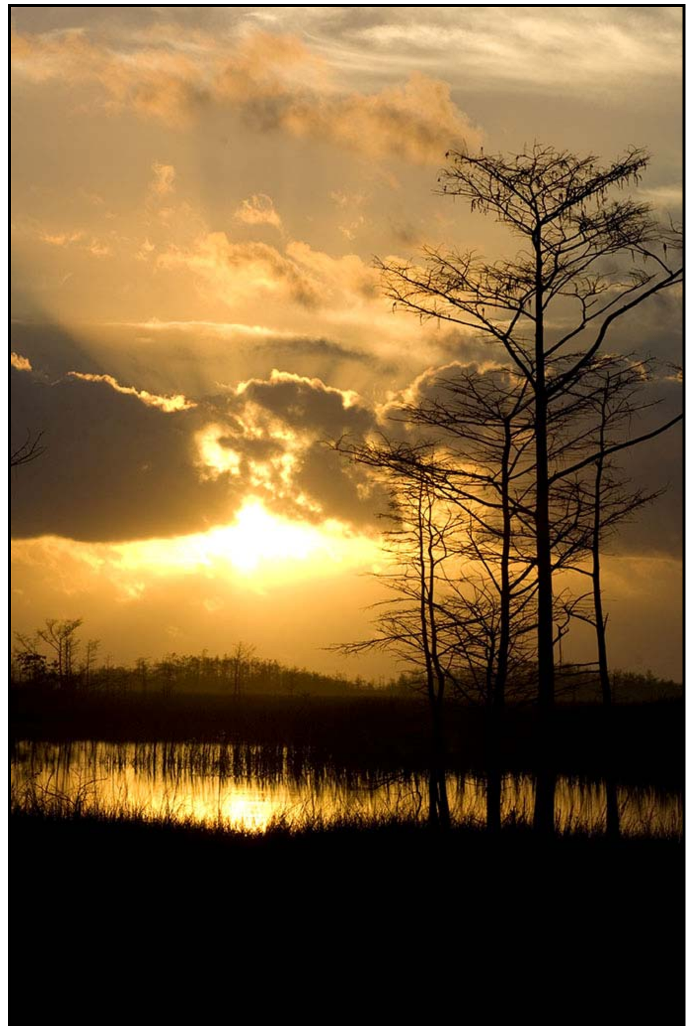

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Table 1. Peak number of wading bird nests in SWA Rookery from February to July 2008

GREG	SNEG	CAEG	GBHE	LBHE	WOST	WHIB	ANHI	TRHE	Total Nests
122	34	451	0	15	154	706	419	66	2042

ROSEATE SPOONBILL NESTING IN FLORIDA BAY ANNUAL REPORT 2007-2008

Methods

Spoonbill Colony Surveys.

Thirty-nine of Florida Bay's keys have been used by Roseate Spoonbills as nesting colonies (Figure 1, Table 1). These colonies have been divided into five distinct nesting regions (Table 1) based on each colony's primary foraging location (Figure 1, Lorenz et al. 2001). During the 2007-2008 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 entailed marking up to 50 nests shortly after full clutches had been laid and re-visiting the nests on a 7-10d cycle to monitor chick development.

Banding Program.

The purpose of this banding program is to understand the movements and population dynamics of the state's spoonbill population. We are interested in the location of post breeding dispersers, the possibility of breeder exchanges between Florida Bay and Tampa Bay, and state-wide regional movements of the general population. 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 senior author or our website (http://www.audubonofflorida.org/who_tavernier_reportspoonbills.html).

Table 1. Number of ROSP nests in Florida Bay Nov 2007-March 2008. An asterisk (*) indicates colony with nesting success surveys (see Table 2).

Sub-region	Colony	2007-08	Summary since 1984 Min	Mean	Max
Northwest	Sandy*	80	62	154.09	250
	Frank	42	0	53.06	125
	Clive	27	11	27.00	52
	Palm	55	9	24.00	55
	Oyster	0	0	6.06	45
	Subtotal	204	65	211.22	325
Northeast	Deer*	15	2	6.67	15
	Tern	0	0	104.57	184
	N. Nest	2	0	0.25	2
	S. Nest	13	0	18.28	59
	Porjoe	10	0	28.55	118
	N Park	0	0	18.00	50
	Duck	1	0	1.94	13
	Pass	0	0	0.50	4
	Subtotal	41	41	177.83	333
Central	Calusa*	13	0	12.50	21
	E. Bob				
	Allen	0	0	13.89	35
	Manatee	3	0	0.19	3
	Jimmie Channel	14	6	19.83	47
	Little Pollock	0	0	2.44	13
	S. Park	0	0	10.61	39
	Little Jimmie	0	0	6.00	12
	First Mate	1	1	1.00	1
	Captain	1	1	5.00	9
	Black Betsy	4	4	4.00	4
	Subtotal	36	15	52.94	96
Southwest	E. Buchanon	0	0	6.13	27
	W. Buchanon	0	0	3.40	9
	Barnes	0	0	0.27	3
	Twin	1	0	1.67	8
	Subtotal	1	0	10.13	35
Southeast	Stake*	11	0	5.44	19
	M. Butternut	3	1	20.67	66
	Bottle	11	0	11.41	40
	Cowpens	2	0	5.88	15
	Cotton	0	0	0.00	0
	West	1	0	2.93	9
	Low	0	0	0.00	0
	Pigeon	17	0	9.38	56
	Crab	0	0	2.13	8
	East	0	0	3.35	13
	Crane	1	1	12.81	27
	E. Butternut	9	0	5.87	27
	Subtotal	55	39	79.80	117
Florida Bay Total		341	341	543.94	880

In Florida Bay, spoonbill nestlings were banded at 10 of the 24 colonies where spoonbills nested. In Tampa Bay, we banded spoonbills at the largest colony in the region, Richard T. Paul Alafia Bank Bird Sanctuary (Alafia Bank, Hillsborough Bay), the state's largest mixed colonial waterbird colony. The ten colonies in Florida Bay were distributed among four regions: Northwest (n = 1), Northeast (n = 3), Central (n = 2), and Southeast (n = 4). Three colonies in the northwestern region can experience heavy predation by American Crows when disturbed by humans and were omitted from the banding program

Details of the banding procedure are described in Lorenz et al. 2007, with the exception that banding did not occur at the Washburn Jr. Sanctuary in 2008.

Spoonbill Monitoring Results

Northwestern Region: Sandy Key

All five colonies in the Northwestern region were surveyed in 2007-08 (Table 1). We counted a total of 204 nests, which is below the average of the last 23 years.

Nest success surveys were conducted at Sandy Key on Oct 16, 24, Nov 6, 20, 27, Dec 6, 11, 21, Jan 1, 9, 17, 23, Feb 9, and Mar 7. All nests were initiated within 17 days of one another, which is somewhat synchronous compared to recent years. We estimate that the first eggs were laid on Nov 18 and the last on Dec 5. The mean laying date was Nov 25, and the mean hatch date was Dec 15. The number of nests found on Sandy Key (n = 80) was well below that normally counted since 1984 (mean = 154). We marked 53 nests for revisitation but were able to follow the outcome of only 21 nests due to the composition of the colony. Of these 21 nests, 90% were successful at raising chicks to at least 21d old (the age when they first leave the nest) and they produced an average of 1.76 chicks per nesting attempt (c/n) which is above average of the past 23 years (1.30 c/n; Table 2).

Table 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	2007-2008	Min	Mean	Max	% of Yrs Successful
Northwest	Sandy	1.76 (90%)	0.00	1.30	2.5	67%
Northeast	Deer	1.77 (87%)	0.00	0.84	2.2	36%
Central	Calusa	.92 (50%)	0.00	0.82	1.71	27%
Southeast	Stake	1.2 (80%)	0.14	0.98	2.09	33%

The threshold fledging rate for a successful nesting is at least one c/n on average. Total production for Sandy Key was estimated at 140 chicks fledged. This figure may be an over-estimation, as no more than 40 fledglings were observed outside the colony, and was probably a result of only calculating productivity based on the outcomes of 21 of 53 nests. We have seen in the past that although chicks reach the 21-day benchmark, the colony can subsequently experience a catastrophic collapse, which may also account for the low fledgling count. Sandy Key nesting was successful in 2007-08 (as defined by the number of chicks reaching 21 days) but care should be taken when interpreting this result given the limitations of the data.

Thirty nestlings from 13 nests were banded at the Sandy Key colony (Table 3) between Dec 21 and Jan 17. Only 20% of the banded chicks were observed post-fledging on the fringes of the colony, and 73% of the banded chicks were never observed alive or dead. Based on band resightings, nesting success was estimated at only 0.46 c/n, much lower than the 1.76 c/n estimate based on nest monitoring. Only one fledgling remained on the island by the Mar 7, 2008 survey.

Northeastern Region: Deer Key

All eight spoonbill nesting colonies were surveyed in the Northeastern region of Florida Bay. Only 41 nests were found, which is well below average, and is the lowest nest count for this region during the period of continuous monitoring (Table 1). Only five of the eight colonies were active during the 2007-08 nesting season.

Spoonbills have nested on Tern Key since monitoring began in 1983-84, but nesting was absent here during the 2007-08 breeding season. The lowest previous count was 60 nests in the 1998-99 nesting season. We used Deer Key as a surrogate for Tern Key as it was the largest nesting colony in the Northeastern region this nesting season. Note that Mean values for Tables 1 and 2 represent the historical focal colony for the sub-region, not for the individual colony, as Deer Key has not traditionally been the focal colony for Northeastern Florida Bay.

Spoonbill nest success surveys were conducted at Deer Key on Oct 18, Nov 3, 19, Dec 5, 19, Jan 4, 10, 18, 25, and Feb 21. As in recent years, the nesting effort for the main focal colony was alarmingly small: only 15 nests in 2007-08 compared to almost 200 nests ten years ago and over 500 nests twenty-five years ago (for the previous main focal colony, Tern Key). At Deer Key, the first egg was laid on Dec 1 and the last on Dec 17; the mean laying date was Dec 10, and mean hatching date Dec 30. Again, nesting was somewhat synchronous and occurred within a 16-day period. We believe this decline in northeastern Florida Bay is due to water management on the foraging grounds. Although this effort is small for the sub-region, this is the largest nesting effort for Deer Key since nests were discovered there in 2005-06. Deer Key birds were also relatively successful producing an averaging of 1.77 c/n compared to the average of 0.84 c/n since 1984 (Table 2). All 15 of the nests initiated on the island were marked for revisitation. Of these, 87% were successful at raising chicks to 21d old. Total production for the colony was estimated at 23 chicks.

In the northeastern region, 36 nestlings were banded from 18 nests within 3 colonies (Deer, South Nest, and North Nest Keys; Table 3). Chicks were banded between Jan 4 and Jan 18. Sixty-seven percent of the banded chicks were observed post-fledging but before they abandoned their natal colony for an estimated production of 1.33 c/n, an average slightly below that estimated by the Deer Key colony surveys. This high productivity and success rate along with Deer Key's much better than average nest success is a hopeful sign that those birds that nest in the Northeastern region, albeit in small numbers, are able to successfully produce young.

A very small second nesting event (three nests) did occur at Deer Key in mid-February. This number provides some support for the hypothesis that second nesting is populated by birds that failed to produce or fledge young in the primary nesting. The second nesting yielded two successful nests with an average of one chick reaching 21d post-hatching per nest attempt. We observed 3 fledglings at the colony post-nesting.

Southeastern Region: Stake Key

All of the twelve Southeastern colonies were surveyed for nesting activity in 2007-08 (Table 1).

Nest success surveys were conducted at Stake Key on Oct 17, 30, Nov 13, 27, Dec 12, 19, 31, Jan 8, 15, 21, 28, and Feb 29. The first egg was laid on approximately Nov 28, with a mean lay date of Dec 9. The mean hatch date was Dec 29. Eleven nests were initiated on the island. On average, each nest attempt produced a successful 1.2 c/n.

We banded 35 nestlings from 19 nests within 4 colonies (E. Butternut, Stake, Pigeon, and Bottle Keys, Table 3). Chicks were banded between Dec 31 and Jan 16. Approximately 9% of these chicks were found dead before leaving their nests, and 51% were observed alive post-fledging before they abandoned their natal colony. Based on the banding effort, the success rate in the Southeastern region was 0.95 c/n, only slightly less than the Stake Key survey estimate.

The success rate observed through nest surveys is greater than last year's 0.92 c/n attempt at Stake Key, and is also above the average 0.98 c/n since 1984. Historically, birds at the southeastern colonies foraged primarily in 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 fared poorly: 8 of 12 years surveyed were failures (Table 2). The success of Stake Key birds is an exception to the historical trend. However, based on previous work (Lorenz et al. 2001) it appears that the quality of the Southeastern region for nesting spoonbills is marginal at best, thereby explaining the low overall effort. Prior to the Keys land boom spoonbills nesting in the Southeastern region successfully produced on average >2.00 c/n (Lorenz et al. 2002).

Figure 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 locations of fish sampling sites are represented by green circles.

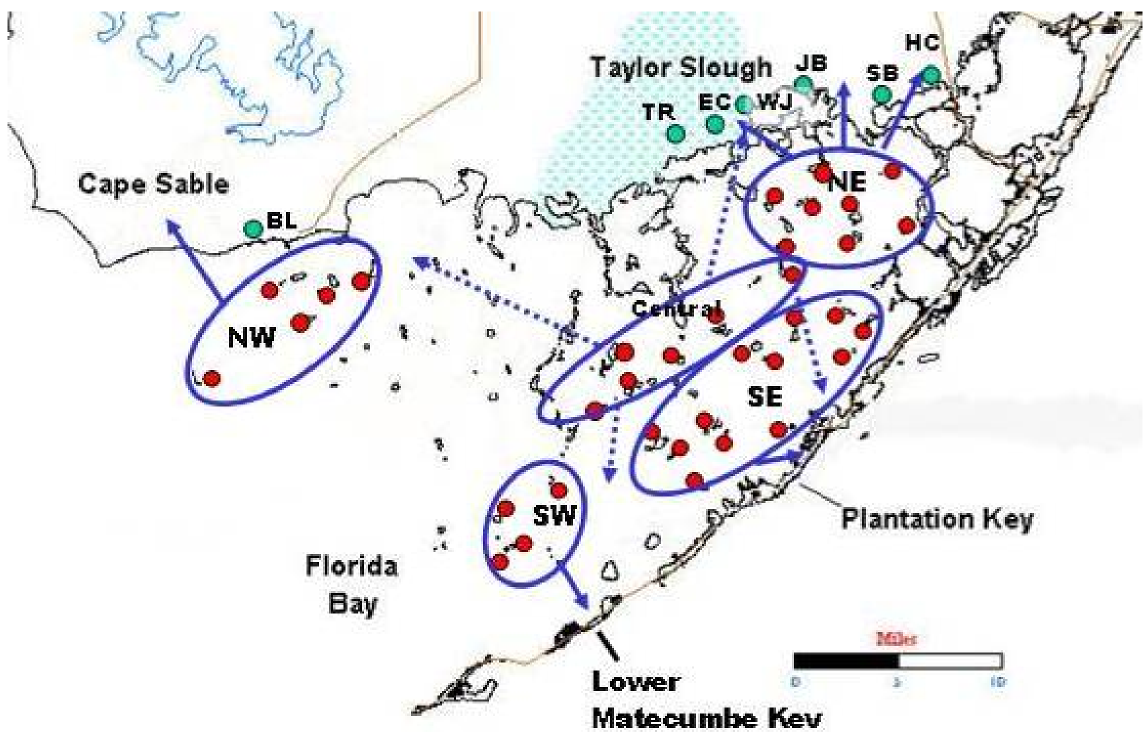

Table 3. Number of ROSP banded in Florida Bay Dec 2007-Feb 2008, and in Tampa Bay, April 2008-May 2008. "Number of ROSP Resighted Alive" indicates the number of birds resighted after the age of 21+ days.

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	13	30	6 (20%)	2 (7%)	22 (73%)
	Northeast	Deer	11	20	15 (75%)	0	5 (25%)
		S. Nest	6	14	8 (57%)	0	6 (43%)
		N. Nest	1	2	1 (50%)	0	1 (50%)
	Central	Calusa	9	16	7 (44%)	1 (6%)	8 (50%)
		Jimmie Channel	10	18	3 (17%)	5 (28%)	10 (55%)
	Southeast	Stake	6	11	8 (73%)	2 (18%)	1 (9%)
		E. Butternut	2	2	1 (50%)	0	1 (50%)
		Pigeon	6	10	4 (40%)	0	6 (60%)
		Bottle	5	12	5 (42%)	1 (8%)	6 (50%)
		Florida Bay Total	69	135	58 (43%)	11 (8%)	66 (49%)
Tampa Bay		Alafia Bank	34	62	52 (84%)	0	10 (16%)

Central Region: Calusa Key

A new nesting colony was discovered this year in the Central region for a total of ten colonies totaling 36 nests (Table 1). This new colony consists of one red mangrove on a mud bank along Black Betsy Key, and although not technically part of the main island of Black Betsy, it is named as such because of its proximity to the main island.

Nesting success surveys at Calusa Key were conducted on Oct 22, Nov 5, 15, 29, Dec 7, 12, 20, 31, Jan 8, 15, 22, 28 and Mar 6. Thirteen nests were found on Calusa, which is slightly above average (12.5 nests since 1984). The first egg was laid on Nov 20, and the last on Dec 7, with a mean laying date of Nov 29 and mean hatching date of Dec 19. This year's nesting was not successful, only 50% of the nests successfully raised chicks to 21d and produced on average only 0.92 c/n. This year was slightly more productive than last year (0.76 chicks per nest attempt, 52% successful nest attempts). Total production for the colony was estimated at 12 chicks, and this was confirmed through colony surveys.

We banded 34 nestlings from 19 nests within 2 colonies (Jimmie and Calusa Keys, Table 3) in the Central region. Chicks were banded between Dec 12 and Jan 15. Approximately 29% of the banded chicks were observed post-fledging before they abandoned the natal colony. The banding effort estimate for production was 0.52 c/n, much lower than the survey estimate.

Significant nesting in the Central region is a relatively new phenomenon, having started in the mid-1980s. As such, little information has been collected on where these birds feed, but the central location 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 1). This catholic foraging style may cost a little more energetically (longer flights to foraging areas), but the increased likelihood of 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 affected negatively. If these foraging grounds do not support abundant and concentrated prey, long flights to more productive areas may be too energetically demanding for a spoonbill to make, resulting in lower nest success. Based on flight-line counts and fixed-wing aircraft observations, it appears that the birds from the Central region are flying over the Russell and Black Betsy Keys to the Taylor Slough area to forage.

Southwestern Region: Twin Keys

All keys in the southwestern region were surveyed multiple times in 2007-08 but only one nest was found on Twin Key (Table 1). This nest did produce young, and two chicks were observed post 21 days hatching.

Bay-wide Synthesis

Bay-wide, Roseate Spoonbills nest numbers in 2007-2008 were the lowest on record (341 nests; Table 1), indicating a continued downward spiral that began with completion of major water management structures in the early 1980s. Historically, the Northeastern region was the most productive region of the bay (Lorenz et al. 2001). 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 Deer Key was extraordinary and exceeded the 0.84 c/n average since 1984; however, the overall effort was astonishingly low for a focal colony, and the total number of nests for the Northeastern sub-region was abysmal. The historical focal colony of the Northeast bay, Tern Key, did not produce a single nest. Nest efforts and success rates at Tern Key have been decreasing for several years, but not since the early 1960s have birds completely abandoned the colony.

In all, 135 chicks were banded from 69 nests across Florida Bay. Of these 8% were observed dead either before leaving the nest or outside the colony and 43% were observed alive post-fledging. No birds have been resighted outside of their natal colonies.

Comparison to Tampa Bay Nesting Population

We began banding spoonbill nestlings at the 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 2.0 c/n 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 1.0 c/n. Tampa Bay 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. Answering this question is critical to demonstrating the causal relationships between Everglades management and the observed decline in Florida Bay.

In 2008, spoonbills nested in 10 colonies (Clearwater Harbor I-25, Belleair Beach, Dogleg Key, Coffeepot Bayou, Alafia Bank, Washburn, Washburn Jr., Dot Dash, Roberts Bay, and Lake Somerset) in the greater Tampa Bay area, although two of the colonies occupied in 2007 (Miguel Bay in Terra Ceia Bay and Little Bird Key National Wildlife Refuge in Boca Ciega Bay) were not occupied in 2008 and nesting occurred at two new colonies: Belleair Beach (1 adult and a fledged brood of 3) and Lake Somerset inland in Polk County (2 nests, with unfledged broods of 2 young and 1 young as of July 5). This is the first nesting report for Lake Somerset (Hodgson and Paul *in prep*.). The largest colony in the region is the Richard T. Paul Alafia Bank Bird Sanctuary in Hillsborough Bay, with 270 pairs (based on a flightline survey conducted on May 1, adjusted by seasonal productivity data) in 2008. A total of 172 fledged birds were observed during one survey of the Alafia Bank colony this season.

We conducted banding for the Tampa Bay area only at the Alafia Bank this year. The Little Bird Key ("Washburn Jr.") colony in Terra Ceia Bay, usually the second largest colony regionally, was occupied early in the nesting season and spoonbills had commenced building platforms when the colony was checked on Apr 9. We observed at least 12 pairs, which was much fewer than in 2007. At a follow-up inspection on May 15 we determined that a raccoon had apparently swum out to the island, which is only about 150 m offshore from a populated area, in the intervals since our earlier visit because we found raccoon tracks and most of the colony had been abandoned. The spoonbills had left Washburn Jr. and we found a few building new platforms at the Nina Griffith Washburn Sanctuary about 2.6 km north. Spoonbills had been nesting at Washburn through 2005, but have not nested there in normal numbers the past two nesting seasons, probably due to a predator we have not been able to remove.

At the Alafia Bank, we banded 62 nestlings from 34 nests during three banding sessions on May 7, 21 and 23 (Table 3). Of the 62 nestlings banded, we resighted 52 (84%) of them alive as fledglings through July 9. Only 10 of the total birds banded were not resighted as of Jul 9. Based on our estimation of 1.53 fledged c/n (52 resighted nestlings/34 nests), we expect about 413 spoonbills (270 nests @ 1.53 c/n) fledged from the Alafia Bank. Based on the estimates from Alafia Bank, and our direct counts or flight line estimates of spoonbill nests at the other occupied colonies this year we estimate a total of ≥441 chicks fledged from ≥327 total nests (≥1.44 c/n) in 10 colonies in Tampa Bay. Spoonbill nesting was affected by low rainfall and summer drought in the two summers preceding this nesting season, followed by heavy rainfall early this spring, which discouraged birds at the beginning of the nesting season and caused a slower onset of spoonbill nesting. From late March to mid-June water levels fell low through a bad drought, then in early July we had heavy rainfall just as the spoonbills were trying to bring off their fledges and, going into the end of the fledging period, the water levels are way up and forage availability is becoming limited so that fledges that should have already left the

Alafia Bank are still standing on the shoreline and do not appear to be thriving.

In Tampa Bay, we banded 164 chicks in April 2003, 233 chicks in 2004, 105 chicks in 2005, 264 chicks in 2006, and 162 chicks in 2007, for a total of 928 chicks. Since then we have received resight reports for over 207 (22.3%) of those birds. These birds were resighted in Brevard, Charlotte, Collier, Duval, Flagler, Hendry, Hernando, Hillsborough, Lake, Lee, Manatee, Marion, Miami-Dade, Monroe, Nassau, Orange, Palm Beach, Pasco, Pinellas, Polk, Sarasota, St. John's, Taylor, and Wakullah Counties. Banded birds have frequently been observed at Merritt Island, Ding Darling, St. Marks, and Loxahatchee National Wildlife Refuges. Of those resighted birds, 5 birds were observed in Georgia. Over 90 birds have been resighted more than once, with one bird having been resighted 13 times at the St. Augustine Alligator Farm. Three of the birds that were resighted in Georgia in 2004 and 2005 were resighted in 2006 and 2007 back in the Tampa Bay area. Twenty-seven birds have been resighted at the St. Augustine Alligator Farm in the past five years.

In 2007, a Tampa Bay bird banded in 2003 nested at Gatorland in Orlando. This was the first documented banded bird to reach reproductive maturity and breed. This bird was successful at fledging two young, and returned to Gatorland in 2008. The spoonbill nested again, hatched two chicks, but was not successful at fledging them.

Of the 267 resightings reported from across the state, 207 (78%) were birds banded in Tampa Bay and only 60 (22%) were banded in Florida Bay. Florida Bay birds have been resighted in Brevard, Collier, Hendry, Hillsborough, Lee (Ding Darling), Miami-Dade, Monroe, Nassau, Palm Beach, Pinellas, St. Johns, and Wakullah Counties. 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 to be less than that of healthy spoonbill nesting areas, including the highly industrialized habitats of Tampa Bay. It is also interesting to note that the rapid growth of spoonbill numbers in Tampa Bay coincides with the rapid decline in spoonbill numbers in Florida Bay since the early 1980s. 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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Lorenz JJ, Ogden JC, Bjork RD, Powell GVN (2001) Nesting patterns of Roseate Spoonbills in Florida Bay 1935-1999: implications of landscape scale anthropogenic impacts. In: Porter JW, Porter KG (eds) The Everglades, Florida Bay and coral reefs of the Florida Keys, an ecosystem sourcebook. CRC Press, Boca Raton, FL p 555-598

HOLEY LAND AND ROTENBERGER WMAs

Systematic wading bird surveys were not conducted this year in Holey Land or Rotenberger WMAs.

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BIG CYPRESS NATIONAL PRESERVE

Systematic wading bird surveys were not conducted in Big Cypress in 2008.

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SOUTHWEST COAST

This year the coastal waterbird nesting season started in early December at Marco and Chokoloskee with a few Osprey nests, followed shortly thereafter by Brown Pelicans and Double-crested Cormorants. Pelican and cormorant nests increased rapidly but failed by end of February, possibly due to starvation given the number of deserted nests and starving chicks. In February pelicans and cormorants renested at the two deserted colonies. Great Egrets started nesting in February (early) at Marco and Chokoloskee and at Smokehouse Key. Reddish Egrets also started at Marco and Smokehouse in February. The small waders (Snowy Egrets, Little Blue and Tricolored Herons and Cattle Egrets) started nesting relatively late, at the beginning of May. Numbers of nests for most of the species in the colonies was low (712 nests), approximately half that of the average of the past 26 years. However, it appears that food availability improved during the season, as many nests appeared to be raising good numbers of chicks by July. There does not seem to be the usual second wave of wader nesting and it is too early to tell how the year will turn out.

Hydrology

The coastal ponds at Rookery Bay dried down completely this year as they did last year. The pond dry-down mimicked last year almost exactly until June when the rains started and pond levels went up dramatically to the point that at the end of the month they were 20% higher than the 26 year mean.

Location and Methods

We changed the nest censusing methods again this year due to the amount of debris left in the understory of the colonies by hurricane Wilma and the exceptional dense growth of the remaining live mangrove (see each colony description for details).

Rookery Bay (RB): 26°01'51"N 81°44'43"W. This year one Red Mangrove island, 0.14 ha. Nest census conducted 7/8, by boat, two observers, 0.5 hour.

Marco Colony (ABC): (named, ABC Islands by State of Florida): 25°57'24"N 81°42'13"W. Three Red Mangrove islands, 2.08 ha. Nest census conducted 6/12, one observer, walk through three hours.

Smokehouse Key: (SK): 25°54'51"(.476)N-81°42'52"(.838)W. One island in Caxambas Pass, 0.8579 hectares (Red Mangrove; a little terrestrial vegetation on sand ridge in center). 6/13, by boat, one observer, 1 hour,

East River (ER): 25°55'39"N 81°26'35"W. Three Red Mangrove islands, 0.25 ha. Nest census conducted 7/2, by canoe, complete coverage, two observers, 1 hour.

Chokoloskee Bay (CHOK): 25°50'43"N 81°24'46"W. Four Red Mangrove islands, 0.2 ha. This year waders used all four islands, by boat, 6/20, two people, 1 hour.

Note: All of the censuses are conducted during peak nesting and this varies according to species and timing.

Sundown Censusing

For two of the colonies above, birds coming in to roost for the night are censused at sundown; the goal of this project is to get an index of the numbers and species in the area, year round. References below as to the use of the area by the different species are derived from this project.

Marco Colony (ABCSD)

Censused monthly with two boats and various numbers of volunteers (4-8). Boats were anchored in the two major flyways (North and East), and we recorded the number and species of birds flying in to roost (and out during the nesting season) one hour before sunset to one half hour after sunset. This project is ongoing and started in 1979.

Rookery Bay (RBSD)

Censused every two weeks with one boat and two observers (one a volunteer). The boat was anchored so that most of the birds can be observed flying in one hour before sunset to one half hour after sunset. We recorded species and numbers of birds flying in to roost (and out during the nesting season). This project is ongoing and started in 1977. At the beginning of the year numbers coming in declined more than usual. For several weeks in the beginning of June there were no waders coming in, two weeks later the numbers slowly started to increase and as of this writing there were about 50% less than the 32 year mean.

Species Accounts

Great Egret

Started early in February at both Marco and Chokoloskee, about on schedule at Smokehouse (April) and late at Rookery Bay (July). Number of nests were above the mean (see Table for peak numbers of nests), and at the time of writing were producing good numbers of chicks. To date this is the only species that has attempted to nest at Rookery Bay this year, and it remains to be seen if they are successful or not. At the Marco colony on 7/4 approximately 50 adults in breeding plumage

Table 1. Peak Wader Nests Coastal Southwest Florida 2008.

Colony	GBHE	GREG	SNEG	LBHE	TRHE	REEG	CAEG	WHIB	GLIB	Total
Rookery Bay		8								8
Marco	14	106	45	9	93	12	63		7	349
Smokehouse Key		25	35		26	4				90
East River			11	3	80			15		109
Chokoloskee Bay	1	136	19							156
Total	15	275	110	12	199	16	63	15	7	712
Mean (26 year)	12	208	262	53	426	5	372	38	43	1419

appeared in the middle of the A island, but did not breed. Throughout the first half of this year the numbers of Great and Snowy Egrets would fluctuate considerably (several times increasing to over three times the 34 year mean for the 32 kl. transect, censused every two weeks north of Marco Island; we suspect the additional birds were transients looking for food.

Snowy Egret, Little Blue Heron, Tricolored Heron and Cattle Egret
With slight variations, all species had similar nesting patterns and will be discussed together. Nesting started later, in smaller numbers (Table 1), and with reduced nesting success.

Reddish Egret
This species has been slowly increasing over recent years and this season produced the highest number of nests ever recorded (16). The first nesting after Wilma (2006) they nested low in storm debris with an average number of nests (5). Then in 2007 the number of nests increased to nine, also in low storm remains. This year many of the nests are in the dense new growth of the remaining live mangrove. Nests are currently being built in the new vegetation from about 30 feet high to several feet above the water. Three nests have been built very low in the storm remnants; one of these was deserted and the other two have produced chicks.

White Ibis
This species did not attempt to nest at Marco or Smokehouse this year but appeared in good numbers at East River at the beginning of July and had 15 nests (Table 1). It will be interesting to see what they will do there.

Glossy Ibis
With seven nests and no fledglings, not much can be said for this species.

Sundown Censusing
For the herons and egrets the numbers coming in at the Marco colony (ABCSD) to roost at night reflect the nesting trends. White Ibis, however, nested in much smaller numbers relative to their roosting patterns. As an example, 15 White Ibis nests were counted at East River on July 2, but the count coming in to roost on July 5 at the ABC islands was 10310 White Ibis. The 20-year mean for total (adult/immature) White Ibis is 9343; just seven of the 20 censuses were higher than this July. Fourteen percent of these birds were this year's fledglings; this is equal to the 20 year mean for the project. Wonder where they found the food?

What is most impressive about all this is that no matter what (storms, people or environmental change) coastal waterbirds keep using the same colonies in what ever condition. It would be easy to believe that with so much change going on, the birds would try to find somewhere else to live. That they keep trying at the same old places; really is a testament to the value of those islands.

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UPCOMING MEETINGS

American Ornithologists' Union, 127th Stated Meeting. 12-15 Aug 2009. Philadelphia, Pennsylvania.
www.birdmeetings.org/aou2009/

Cooper Ornithological Society Annual Meeting. 16-18 April 2009. Tucson, Arizona.
www.birdmeetings.org/cos2009/

Society for Canadian Ornithologists Annual Meeting. 20-23 Aug 2009. Edmonton, Alberta.
www.sco-soc.ca/meetings.html

The Wildlife Society Annual Conference: 20-24 Sept 2009. Monterey, California.
www.wildlife.org/

WADING BIRD COLONY LOCATION, SIZE, TIMING, AND SUCCESS AT LAKE OKEECHOBEE

Introduction

Systematic aerial surveys of wading bird nests on Lake Okeechobee (hereafter The Lake) began during the early 1970s and were continued by several investigators annually from 1977–1992 and 2005-2007. During that period wading bird nest counts for the 5 species historically surveyed (White Ibis, Glossy Ibis, Great Blue Heron, Great Egret, and Snowy Egret) ranged from a high of 10,868 nests in 2006 to a low of 130 nests in 1971 (Ogden 1974, David 1994). During the recent drought year of 2007, Florida Atlantic University reported the third lowest counts of nests (550) for the 5 species at The Lake (Marx and Gawlik 2007). Drought conditions continued in to 2008 (Fig. 1), breaking records for the duration of low water levels at The Lake, and setting the stage for the lowest reported counts of nesting wading birds since surveys were initiated in the 1970s.

Methods

Florida Atlantic University conducted wading bird nesting surveys to determine the size and location of wading bird colonies on The Lake as part of the CERP Monitoring and Assessment Plan. During Jan-Feb, the few potential colony sites that existed in the Lake were visited by airboat and it was confirmed that nesting had not yet been initiated. We are not sure about conditions during March. We began formal aerial surveys in April. On 23 April 2008 and 25 May 2008, 2 observers surveyed wading bird nests along aerial transects from a helicopter at an altitude of 244 m (800 ft) and a speed of 185 km/hr (100 knots). One transect paralleled the eastern rim of The Lake from Eagle Bay Island to the Clewiston Lock. Remaining transects were oriented East-West, spaced at an interval of 3 km (1.6 nm), and traversed the littoral zone. Two observers searched for colonies from each side of the aircraft. Colonies were defined as any assemblage of ≥ 2 nests that were separated by ≥ 200 m (Erwin et al. 1981, Smith and Collopy 1995). When a colony was located, we circled the colony, descending to a low of 122 m (400 ft) if needed, to count numbers of nests of each species present. We also recorded photographs and geographic coordinates. We did not make ground visits to determine nesting success.

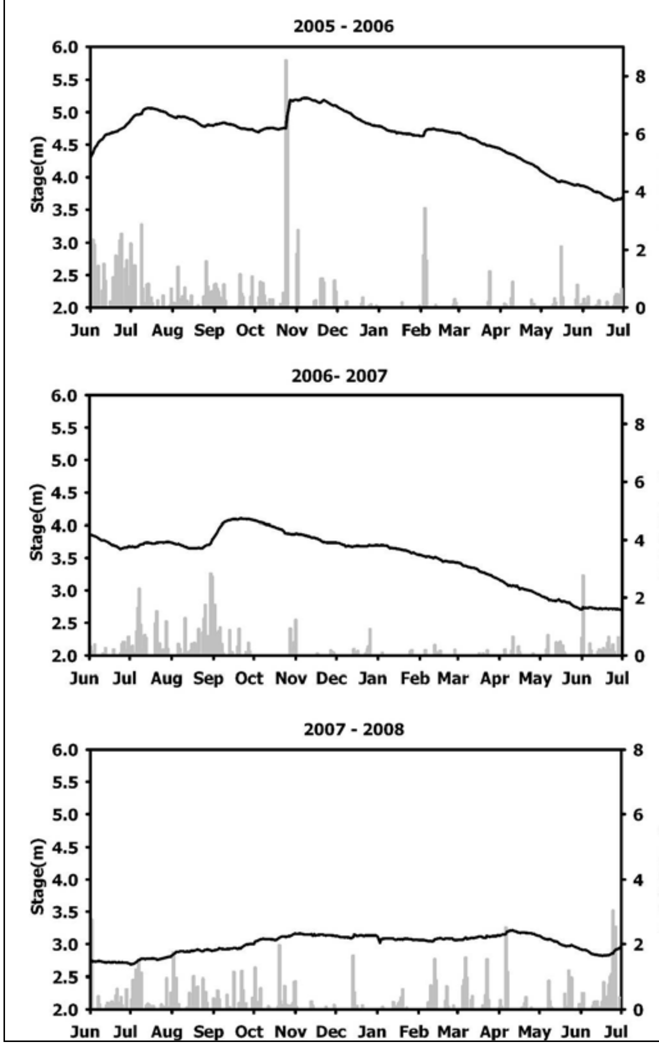
Rainfall and hydrology data were obtained from the South Florida Water Management District's DBHYDRO database. Lake stage is the mean of stage readings from 4 gauges located in the pelagic zone at Lake Okeechobee (L001, L005, L006, and LZ40). Lake stages, reported as feet National Geodetic Vertical Datum 1929 (NGVD29), were converted to meters. Rainfall amount was the mean value from 3 of the 4 gauges (L001, L005, L006) converted from inches to centimeters.

Results and Discussion

Locations

We located 3 wading bird colonies in the Lake Okeechobee area. Eagle Bay Island was within The Lake proper, Lakeport was in the rim canal, and Gator Farm was outside the lake at an alligator farm (Fig. 2). We did not survey the Martin County Florida Power and Light Reservoir. Of the 3 colonies detected this year, only the Gator Farm colony was active in 2007. The Eagle Bay Island colony was active in 2006 and many other years, whereas the Lakeport colony may be a new colony location. While we circled the colony, we noticed that flight lines of birds in and out of the Lakeport colony were to the West, suggesting that birds were foraging in wetlands outside The Lake.

Figure 1. Hydrograph showing rainfall (shaded bars; cm) and lake stage (line; m) on Lake Okeechobee during a water year from 2005-2008. Lake stage is the mean of stage readings from 4 gauges located in the pelagic zone at Lake Okeechobee (L001, L005, L006, and LZ40). Rainfall amount was the mean value from 3 of the 4 gauges (L001, L005, L006).



Size

Season-wide nest effort for all wading birds peaked at 38 nests, excluding Cattle Egrets (Table 1). Nest effort among Great Blue Herons, Great Egrets, Snowy Egrets, White Ibis, and Glossy Ibis, the species that were consistently surveyed in the historic record (David 1994), peaked at 30 nests. This estimate makes 2008 the worst year on record for wading bird nesting at Lake Okeechobee. Counts of those species from 1971, 1981, and 2007, previously the 3 worst years, ranked slightly higher with 130, 520, and 550 nests, respectively. The 3 years had similar

Figure 2. Map of Lake Okeechobee showing active nesting colonies during the breeding season of 2008.

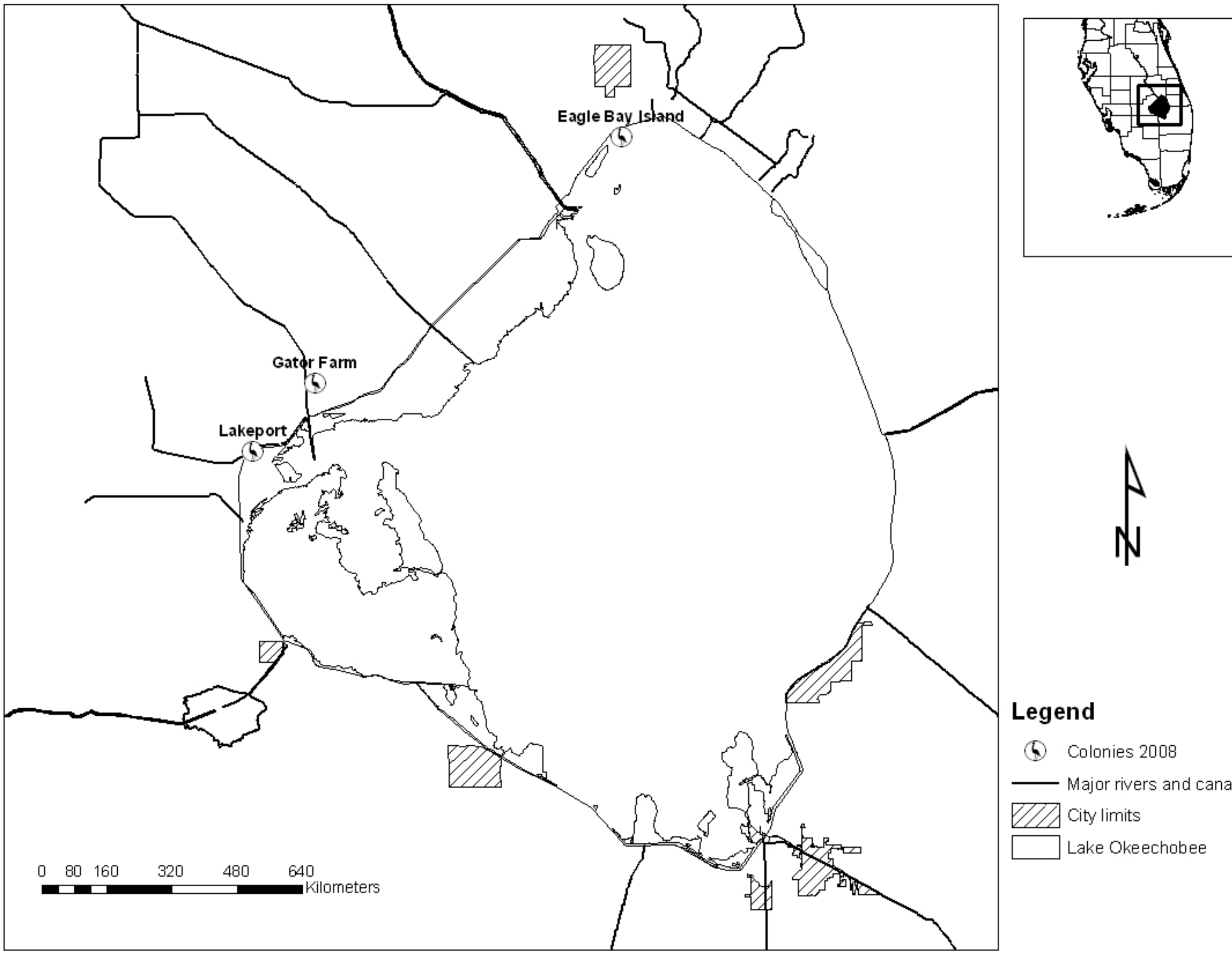


Table 1. Colony locations (NAD 83), individual colony counts of nests for each species, and maximum counts of each species of wading bird detected at Lake Okeechobee during aerial surveys in the 2008 breeding season.

Colony	Latitude	Longitude	Survey date	GBHE	GREG	SNEG	TRHE	LBHE	WHIB	GLIB	WOST	CAEG
Eagle Bay Island	-80°50'13.56"	27°10'45.12"	23-Apr-08	0	0	0	5	5	0	0	0	500
			27-May-08	0	0	0	0	0	0	0	0	3500
Lakeport	-81°07'01.77"	25°58'10.82"	23-Apr-08	0	0	0	0	0	0	0	0	20
			27-May-08	0	1	0	0	0	0	0		2000
Gator Farm	-81°3'38.99"	27°01'22.01"	23-Apr-08	0	20	0	0	0	0	0	0	100
			27-May-08	0	12	0	0	0	0	0	8	500
Peak # nests species				0	21	0	5	5	0	0	8	6000

*Michael Cheek (SFWMD), surveyed the Gator Farm colony by helicopter 1 Jul 08 and counted 6 fledged juvenile WOST at the colony.

hydrological patterns; low lake stages at the start the breeding season and below average rainfall during the preceding wet season, regardless of whether The Lake experienced favorable recession rates. Recession rate is an ecosystem process that concentrates small aquatic animals and creates small patches of highly available prey. The Lake experienced such conditions in 2006, when there were high water levels at the start of the dry season followed by a strong recession, thereby producing the largest number of nesting birds reported since 1974. Similar conditions in the Everglades in 2006 also produced a large nesting event. In 2008, The Lake experienced both low water levels and poor recession rates, making it very likely that hydrologic conditions led to the poor reproductive performance of wading birds. Hydrologic patterns probably acted to reduce prey availability, but we cannot reject the hypothesis that suitable colony sites were also limiting. Wading birds prefer to nest in trees that remain surrounded by water throughout the nesting season and such places were scarce in 2008.

The relationship among hydrologic patterns, habitat, and wading bird nesting is becoming better known (Marx and Gawlik 2006, Marx and Gawlik 2007); however, a second year of low water levels provided new information not evident during the first year of drought. By May of 2007, the littoral zone was completely dry leaving only the open and unvegetated nearshore and pelagic zones as foraging habitat for wading birds (Marx and Gawlik 2007). In 2008, the littoral zone remained dry, but submerged vegetation was established in much of the nearshore zone, probably making it better foraging habitat than in 2007. This shift of vegetation down the elevation gradient suggests that habitat conditions may start to improve after the first year of a lower water regime, be it driven by reduced rain or management. However, we believe it is unlikely that nearshore habitat would ever improve to the level of the littoral zone marsh, even when it has ideal water depths and recession rates. The elevation gradient in the near shore zone is steeper and provides less area of suitable habitat when hydrologic conditions are ideal.

Timing

No wading bird nesting occurred prior to March, but by 23 April, herons and egrets were incubating and storks were building nests. By 27 May, Storks were on small chicks, Great Egret numbers had increased slightly and the small herons were no longer present, suggesting that their nests probably failed. Cattle Egrets increased in numbers from April to May, as is typical for the species. However, the numbers on The Lake this year were extremely high relative to past years. We speculate that the lack of rainfall may have dried many of the wetlands for the first time in many years and opened up a large amount of new foraging habitat for this grassland species.

Wood Storks

A small colony (Gator Farm) containing Wood Storks and 2 other species developed in cypress trees on an alligator farm about 4 km north of Harney Pond along Highway 721, in the same location as last year. On 23 April, there were 22 birds perched in the colony and a number of nest platforms already completed, but no eggs had been laid. By 27 May, there were 8 WOST nests with small chicks, indicating that the adults must have laid eggs shortly after our April survey. On July 1, Michael Cheek (SFWMD) surveyed the colony and noted 6 fledged juvenile storks perched in trees and flying within the colony. This number is down from the 22 chicks that are thought to have fledged the colony in 2007 (Marx and Gawlik 2007).

Acknowledgements

This section is dedicated to the memories of Damion Marx, Philip Heidemann, and Gareth Akerman. Their deaths were a deep loss to many people and a magnificent ecosystem. We thank Mark Cook, Rachael Pierce, and Michael Cheek for assisting with, and facilitating, helicopter surveys. We also thank Bryan Botson for support with hydrologic data.

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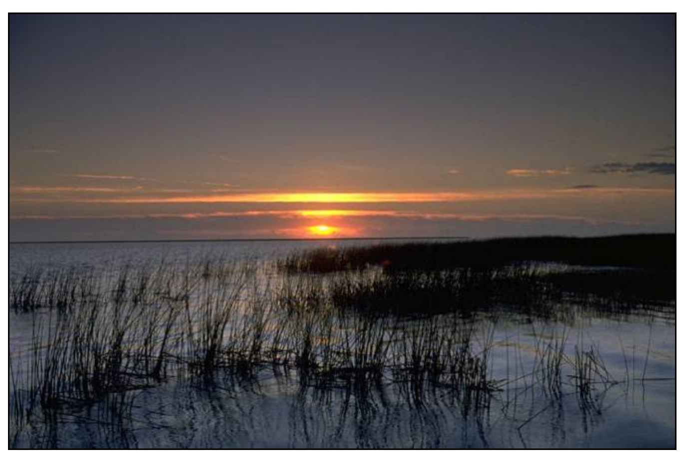


KISSIMMEE RIVER

Introduction/Background

Prior to its channelization, the Kissimmee River, its 1 – 3 km wide floodplain, and surrounding wetland/upland complex supported substantial numbers of foraging and nesting wading birds (National Audubon Society, 1936 – 1959). Between 1962 and 1971, the Kissimmee River was channelized and its headwater lakes regulated, resulting in the drainage of the majority of its floodplain wetlands and a substantial reduction in the number of wading birds (excluding cattle egrets) using the system (Williams and Melvin, 2005). The Kissimmee River Restoration Project, which was authorized in 1992, seeks to restore ecological integrity to the middle portion of the original river system via 1) reconstruction of the physical form of the river (i.e., canal backfilling, removal of water control structures, and recarving/reconnecting river channels); and 2) reestablishment of historical (pre-channelization) hydrologic (i.e., discharge and stage) characteristics through modifications to regulation schedules of headwater lakes. When completed, the project will restore approximately 104 km² of river-floodplain ecosystem, including 70 km of continuous river channel. The restored area is expected to experience seasonal flood pulses and recessions that are favorable for wading bird reproduction. To date, approximately one third of project construction has been completed. All construction is scheduled for completion by the end of 2013; new regulation schedules for headwater lakes will be implemented in 2010. Wading bird responses to the restoration project will be monitored through 2018.

Methods

As part of the Kissimmee River Restoration Project evaluation program, we performed systematic aerial surveys (Jan 29, Mar 27, May 27) to search for wading bird nesting colonies within the floodplain and surrounding wetland/upland complex of the Kissimmee River. Surveys began at the S65 structure at Lake Kissimmee and proceeded southward to the S65-D structure (Figure 1). Observers were placed on both sides of a helicopter flying at an altitude of 244 m along east-west transects spaced 2 km apart. Each transect spanned the 100 yr flood line of the river plus an additional 3 km east and west of the flood line. Nesting colonies were also monitored, when encountered, during separate aerial surveys of foraging wading birds (Jan 10, Feb 7, Mar 6, Apr 10, May 5, Jun 3, and July 1). These surveys were flown at a lower altitude (30 m) and were limited to the area within the 100 yr flood line of the river between S65 and S65-D. Once a colony was located, nesting species and the number of active nests were visually estimated by both observers. The number of nests reported for each colony represents the maximum number of nests for each species. Nesting success was not monitored, but one ground survey (Feb 20) was conducted at the S-65D cypress colony to obtain more accurate nest counts and determine the presence of less visible dark-colored species (i.e. little blue heron (*Egretta caerulea*) and tricolored heron (*Egretta tricolor*).

Results

None of the six colonies previously observed (since 2004) were active during 2008 (Table 1). One small colony containing 2 great egret (*Ardea alba*) and 4 great blue heron (*Ardea herodias*) nests was observed near the S-65D boat ramp in mature cypress during the 2008 season (Fig. 1). As in 2007, long-legged wading birds may have lacked sufficient aquatic prey to initiate breeding due to drought conditions and insufficient inundation of the floodplain for effective foraging. Additionally, the timing and magnitude of floodplain inundation and recession is not yet optimal for rookery formation due to hydrologic operational constraints. Implementation of the regulation schedule for the Headwaters Revitalization Project in 2010 will allow water managers to more closely mimic the historical stage and discharge characteristics of the river, presumably leading to suitable hydrologic conditions for wading bird nesting colonies.

Figure 1. Aerial survey transect routes and locations of nesting colonies within the Kissimmee River floodplain and surrounding wetland/upland complex during 2008.

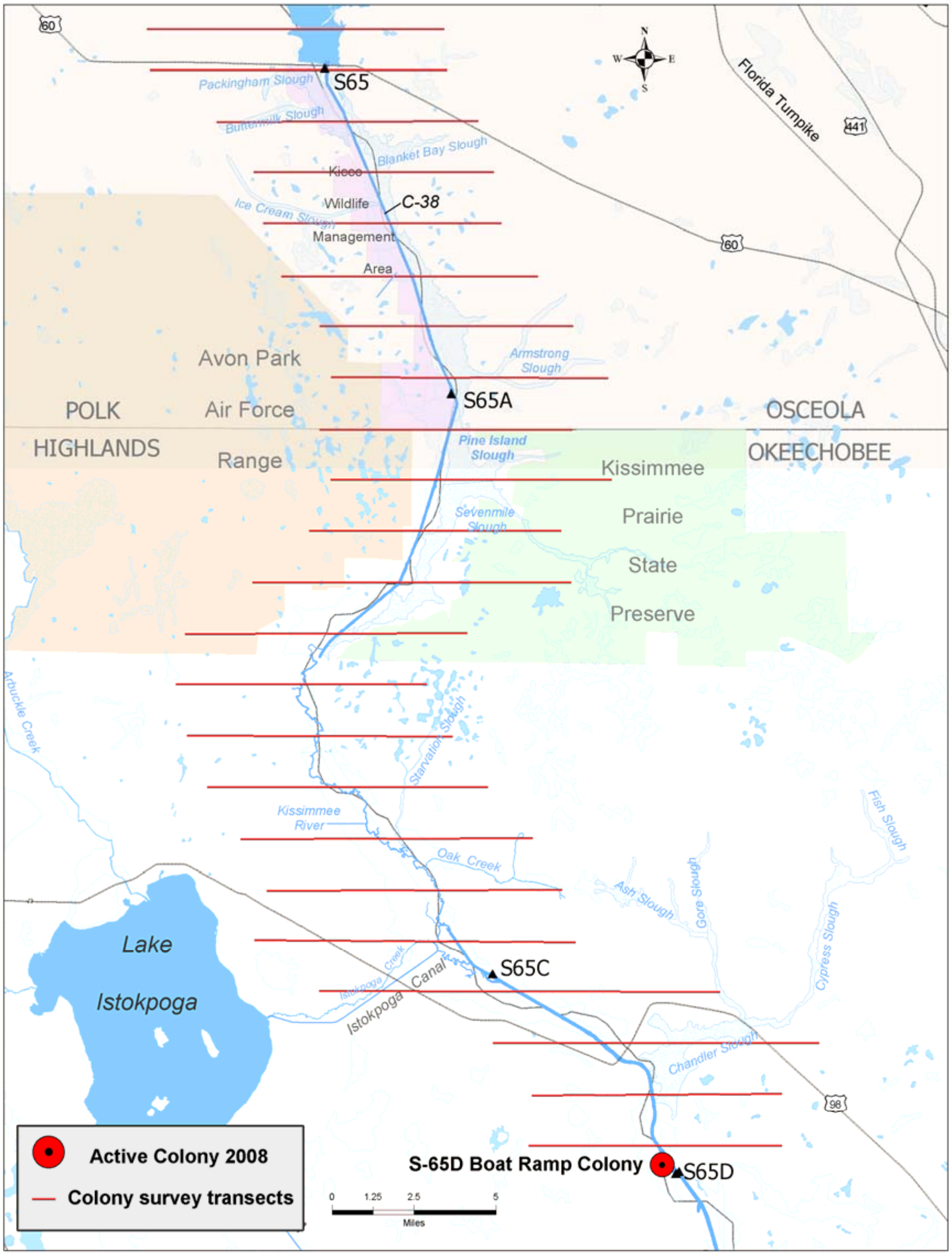


Table 1. Peak numbers of wading bird nesting colonies inside or within 3 km of the Kissimmee River 100 yr flood line between the S65 and S65-D structures. Surveys were conducted Mar-Jun, 2004; Mar-Jun, 2005; Feb-Jun, 2006; May-Jul 2007; and Jan-May 2008.

Latitude	Longitude	Colony Name	Year	ANHI	CAEG	GBHE	GREG	TRHE	Colony Total
			2004	-	-	-	-	-	-
			2005	-	-	-	-	-	-
81 13.219	27 42.946	42W	2006	-	-	-	8	-	8
			2007	-	-	-	-	-	-
			2008	-	-	-	-	-	-
			2004	-	-	-	-	-	-
			2005	-	-	-	-	-	-
81 04.466	27 22.853	C38 Caracara Run	2006	-	500	-	-	-	500
			2007	-	226	-	-	1	227
			2008	-	-	-	-	-	-
			2004	-	-	-	-	-	-
			2005	-	-	-	21	-	21
81 16.527	27 32.088	Cypress West	2006	-	-	-	25		25
			2007	-	-	-	-	-	-
			2008	-	-	-	-	-	-
			2004	-	-	-	-	-	-
			2005	-	-	-	-	-	-
81 00.380	27 22.620	New Chandler Slough	2006	-	-	-	40	-	40
			2007	-	-	-	-	-	-
			2008	-	-	-	-	-	-
			2004	-	-	-	-	-	-
			2005	30	-	5	60	-	95
81 04.649	27 21.076	Orange Grove	2006	20	-	4	60		84
			2007	-	-	-	-	-	-
			2008	-	-	-	-	-	-
			2004	-	-	-	-	-	-
			2005	-	400	-	-	-	400
81 06.442	27 37.791	Pine Island	2006	-	-	-	-	-	-
			2007	-	-	-	-	-	-
			2008	-	-	-	-	-	-
81 01.832	27 19.066	S-65D Boat Ramp	2008	-	-	4	2	-	6
			2004	0	0	0	0	0	0
			2005	30	400	5	81	0	516
Total Nests			2006	20	500	4	133	0	657
			2007	-	226	-	-	1	227
			2008	-	-	4	2	-	6

KISSIMMEE RIVER FORAGING DENSITIES

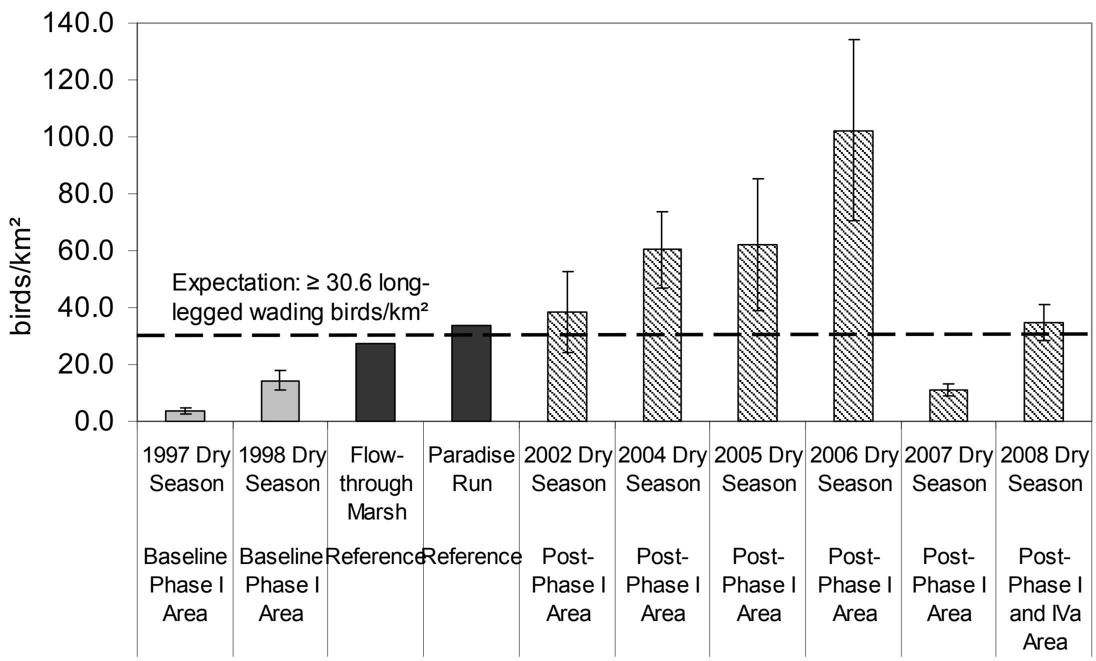
Aerial surveys were used to measure the densities of foraging wading birds within the Kissimmee River floodplain. Surveys were conducted approximately monthly during the baseline period (pre-restoration; 1996–1998) and have continued after Phases I and IVa of the restoration project were completed in 2001 and 2007, respectively. Restoration is expected to bring increased use of the floodplain by long-legged wading birds (excluding cattle egrets). Furthermore, mixed species wading bird rookeries are anticipated to regularly form on and near the floodplain and tributary sloughs once abundant food resources and appropriate hydrology have been reestablished.

East-west aerial transects (n = 218) were established at 200 m intervals beginning at the S-65 structure and ending at the S-65D structure (see Figure 1 for structure locations). Each month, transects were randomly selected for counts until a minimum of 20 percent of the 100-year floodplain was surveyed in both the restored and unrestored portions of the river/floodplain. Surveys were conducted via helicopter flying at an altitude of 30.5 m and a speed of 80 km/hr. A single observer counted all wading birds and waterfowl within 200 m of one side of the transect line. Because it is not always possible to distinguish tricolored herons (*Egretta tricolor*) from adult little blue herons (*E. caerulea*) during aerial surveys (Bancroft et al. 1990), the two are lumped into the category, small dark herons. Likewise, snowy egrets (*E. thula*) and immature little blue herons were classified as small white herons (Bancroft et al. 1990). Densities of wading birds were calculated separately for restored and unrestored areas.

Because no quantitative data are available for densities or relative abundances of long-legged wading birds of the pre-channelized Kissimmee River, restoration expectations for responses by wading birds to the KRRP are based on reference data from aerial surveys of a flow-through marsh in Pool B that was built as part of the Kissimmee River Demonstration Project and for floodplain areas along Paradise Run, a portion of the Kissimmee River near Lake Okeechobee that still retains some channel flow and periodic floodplain inundation (Toland 1990; Perrin et al. 1982). The 3.5 km² flow-through marsh was constructed just south of the S65-A tieback levee during 1984–1985 and was manipulated to simulate inundation and overland flow that were typical of the pre-channelized Kissimmee River floodplain (Toth 1991). Based on these reference data, it is expected that annual dry season (December–May) densities of long-legged wading bird (excluding cattle egrets) will be ≥ 30.6 birds/km².

Prior to Phase I construction (baseline period), mean annual dry season densities of long-legged wading birds in the Phase I area averaged (± SE) 3.6 (±0.9) birds/km² in 1997 and 14.3 (±3.4) birds/km² in 1998. Since completion of Phases I and IVa, densities of long-legged wading birds have exceeded the restoration expectation of 30.6 birds/km² each year except 2007, averaging 37.8 (±15.4), 61.7 (±14.5), 59.6 (±24.4), 103.0 (±31.5), 11.0 (±2.1), and 34.7 (±6.4) birds/km² in the dry seasons of 2002, 2004, 2005, 2006, 2007, and 2008, respectively (2003 data were not collected; Figure 2). Furthermore, the lower limit of the 95 percent confidence interval (95% C.I.) has exceeded the expectation in three of six years.

Figure 2. Baseline, reference, and post-Phases I and IVa densities (± SE) of long-legged wading birds (excluding cattle egrets) during the dry season (Dec-May) within the 100-year flood line of the Kissimmee River. Baseline densities were measured in the Phase I area prior to restoration. Post-restoration densities were measured beginning approximately 10 months following completion of Phase I.



Wading bird numbers this year rebounded significantly from last year's post-Phase I restoration low, when most floodplain foraging habitat was completely dry and the river had no flow for nearly 9 months (Bousquin *et al.* 2007). Foraging conditions on the floodplain gradually improved after summer rains reestablished flow to the river on 18 July 2007. Glossy (*Plegadis falcinellus)* and white ibis (*Eudocimus albus*) dominated numerically, followed in order of abundance by cattle egret (*Bubulcus ibis*), great egret, small white heron (snowy egrets (*Egretta thula*) and juvenile little blue herons), great blue heron, and small dark heron (tricolored herons and adult little blue herons). Federally endangered wood storks were observed within the restored area during surveys in December, February, March, June, and July.

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ESTERO BAY AQUATIC PRESERVE COLONIAL WADING BIRD NEST MONITORING AND PROTECTION PROGRAM

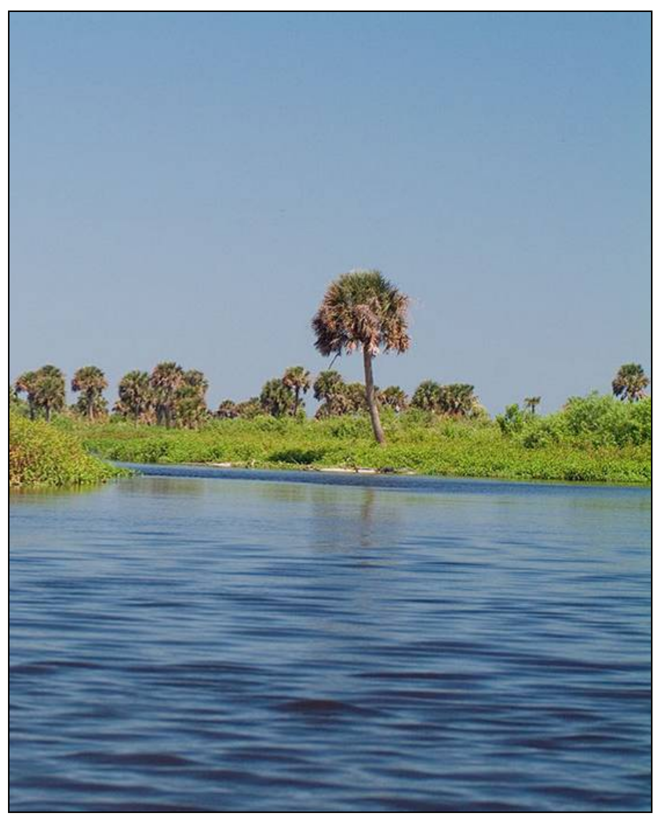
Introduction

Estero Bay Aquatic Preserve (EBAP) was designated Florida's first aquatic preserve in 1966. EBAP consists of 11,000 acres of sovereign submerged lands and is located in south west Florida extending from Fort Myers Beach to Bonita Springs. The shallow estuary is fed by five fresh water tributaries and four passes connecting to the Gulf of Mexico. Designated as Outstanding Florida Waters because of its exceptional ecological significance, Estero Bay contains islands that are used as breeding colonies by a variety of bird species.

Methods

Islands within the aquatic preserve and state owned islands bordering the aquatic preserve were monitored for nesting birds once mid-month starting in March and continuing through the end of nesting season. Historical nesting sites were surveyed along with nesting sites documented for the first time this nesting season. Surveys were conducted on 17 March, 25 March, 1 April, 18 April, 15 May and 20 June.

Surveys were conducted using a 17' Boston Whaler and entailed circling each island while two observers counted the number of nesting pairs and nests by species. Nests were recorded as empty, unknown, incubating or chicks. Survey data collected between March and June was analyzed; however surveys continued through the end of the nesting season.



Results

A total of 15 islands were surveyed including 13 historical islands and two colonies that were initiated this season. Thirteen of the 15 islands had nesting colonies during the 2008 nesting season; Big Carlos Pass M-48 and Big Carlos Pass S of M-48 were inactive. The remaining islands contained an average of 256 nests with a peak of 512 nests, between March and June. In June nine colonies still contained active nests.

Colony summaries

Big Carlos Pass M-43

Double-crested Cormorants, Great Blue Herons, Great Egrets and Tricolored Herons nested on the island this season. Nesting on the island was initiated in April and in May the island reached peak activity with 26 nests. In June two Tricolored Heron nests, with chicks, were active.

Big Carlos Pass M-50&52

In March Double-crested Cormorants and Brown Pelicans were documented on the island. In April only four Brown Pelicans remained on nests and the colony was abandoned by mid-May. No chicks were observed during surveys.

Big Carlos Pass W of M-46

Nesting was initiated in May. Two Yellow-crowned Night-Herons were observed on nests; no chicks were documented and there was no activity on the island in June.

Big Carlos Pass W of M-52

Brown Pelicans, Great Blue Herons and Great Egrets initiated nesting in April and the colony contained 40 nests at that time. In May there was no activity on the island and one Great Egret was observed on a nest in June.

Big Hickory E of M-85

This colony was active throughout the nesting season. Peak activity was observed in April with Double-crested Cormorants, Brown Pelicans, Great Blue Herons, Great Egrets, and a Yellow-crowned Night-Heron totaling 32 nests. In June Four nests remained on the island; two Double-crested Cormorants, one Great Blue Heron and a Great Egret.

Big Hickory M-83

This island was first documented as a nesting island in April of this year and contained nesting Great Blue Herons, Black-crowned Night-Herons, and Yellow-crowned Night-Herons. The island contained 8 nests and all had chicks in June.

Coconut Point East

One Great Blue Heron nest was documented in May as well as two empty nests. In June no nests were recorded. One nest containing a Great Blue Heron chick was observed in February prior to the start of nesting surveys. The island also contained an active Osprey nest which fell down between May and June surveys.

Coconut Point West

This colony started nesting early, and in March contained 37 nests including Brown Pelicans Double-crested Cormorants and one Great Blue Heron. In April only three active nests remained and several empty nests were recorded. In May nine Brown Pelicans and two Great Egrets were nesting. Nest numbers jumped to 29 in June with only Brown Pelicans nesting on the island.

Hogue Channel M-78

Nesting was initiated in April and five nests were still active in June. Yellow-crowned Night-Herons, Black-crowned Night-Herons and Green Herons nested on this island. One adult Green Heron was found entangled in fishing line next to a nest, the heron did not survive.

Matanzas Pass

This island is a spoil island and contains the largest nesting colony in Estero Bay. It is located just north of the aquatic preserve boundary. Nest counts averaged 148 between March and June and the peak number of nests was 161. Double-crested Cormorants, Brown Pelicans, Great Blue Herons, Great Egrets, Snowy Egrets, Little Blue Herons, Tricolored Herons, Reddish Egrets, Cattle Egrets, Black-crowned Night-Herons, Yellow-crowned Night-Herons and Green Herons all nested on the island. In June 140 nests were recorded.

New Pass M-21

Two Great White Heron nests were recorded on this island along with seven Great Blue Heron nests. The Great White Herons were only observed in April and in May one of the chicks was found dead in the nest entangled in monofilament line. In June one Great Blue Heron chick still remained in the nest.

New Pass M-9

Double-crested Cormorants, Great Blue Herons, Great Egrets and Brown Pelicans nested on the island. In May one Great Blue Heron nest was recorded on the island and in June one Great Blue Heron, six Great Egrets and five Double-crested Cormorants were nesting.

North Coconut M-4

In March one Great White Heron was observed nesting on the island; however the nest was empty in April. Double-crested Cormorants, Great Blue Herons and Great Egrets nested on the island in March. In April only Double-crested Cormorants and Great Blue Herons were nesting and by May the island had been abandoned.

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J.N. "DING" DARLING NATIONAL WILDLIFE REFUGE COMPLEX 2008

Methods

Colonial nesting bird surveys at J.N. "Ding" Darling National Wildlife Refuge Complex were conducted in cooperation with the Charlotte Harbor Aquatic Preserve. Surveys were conducted monthly from February through July via motorboat within Matlacha Pass (Givney Key, Lower Bird Island, Lumpkin Island, and Skimmer Island), Pine Island Sound (Broken Islands and Hemp Island), and Tarpon Bay (Tarpon Bay Keys). Colonial nesting bird surveys included both wading birds (herons, egrets, and ibis) and diving birds (brown pelicans, double-crested cormorants, and anhingas). Total nests are derived from the maximum number of nest-tending birds observed for each species during the survey period. Survey dates for all rookery islands within Matlacha Pass were February 19, March 21, April 17, June 11, and July 30. Nesting activity on Givney Key was not initiated until late June. Thus, an additional survey of this island was conducted on July 9. Survey dates for islands within Pine Island Sound were March 28, April 25, May 23, June 27, and July 25. Survey Dates for the Tarpon Bay Keys were February 19, March 21, April 17, June 25, and July 30.

Results

The peak estimate for 14 species of colonial nesting birds from all islands combined was 1,626 nests during 2008 (Table 1). Wading bird nests comprised approximately one-third (503) of those recorded while the remaining two-thirds (1,123) were diving bird nests. Most of the wading bird nests were located on islands in Matlacha Pass (312) while most of the diving bird nests (804) were located on islands in Pine Island Sound. Double-crested cormorant and brown pelican nests were the most abundant species overall and on almost every island surveyed. White ibis nests ranked third overall. However, almost all of their nests were located on Givney Key in Matlacha Pass. Green heron, yellow-crowned night heron, and reddish egret nests were the least abundant overall. Anhinga and green heron nests were only found on islands in Matlacha Pass and almost exclusively on Lumpkin Island. Hemp Island in Pine Island Sound was the largest rookery surveyed with a peak number of 424 nests.

<u>Matlacha Pass:</u> The peak number of nests recorded on the islands within Matlacha Pass was 537 nests, of which 312 were wading bird nests. The three largest rookeries were located on Givney Key, Lumpkin Island, and Skimmer Island (Table 1). The earliest nesting effort recorded in Matlacha Pass was on Skimmer Island in February and on Crescent, and Upper Bird Islands during March but the nests on Crescent and Upper Bird Islands were abandoned by the April survey. Nesting did not begin on Givney Key until after the June survey and were found during an exotic plant survey.

<u>Pine Island Sound:</u> The peak number of nests recorded in Pine Island Sound was 911, of which 107 were wading bird nests and 804 were diving bird nests. The two largest rookeries were located on Broken Islands South and Hemp Island. Nesting effort was initiated in March on every island surveyed except Broken Islands East which was not discovered until June.

<u>Tarpon Bay Keys:</u> The peak number of nests on the Tarpon Bays Keys was 178, of which 84 were wading bird nests and 94 were diving bird nests. Nesting began in February and data suggest two peaks in nesting effort, one in March/April and one in June.

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Table 1. Colonial nesting bird survey peak estimates for J.N. "Ding" Darling National Wildlife Refuge Complex March through July, 2008. Counts reflect the maximum number of nest-tending adults by species.

Island Surveyed	ANHI	BRPE	DCCO	BCNH	GBHE	GRHE	LBHE	TRHE	YCNH	CAEG	GREG	SNEG	REEG	WHIB	TOTAL
Crescent Island	0	7	19	0	1	0	0	0	0	0	0	0	0	0	27
Givney Key	3	9	30	4	3	0	4	6	0	0	3	4	0	201	267
Lower Bird Island	0	37	7	0	0	0	0	0	0	0	0	0	0	0	44
Lumpkin Island	15	0	36	1	2	3	10	15	1	9	3	5	1	0	101
Skimmer Island	2	35	25	0	22	0	1	2	0	0	5	2	0	0	94
Upper Bird Island	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
Broken Islands, E	0	30	47	0	0	0	0	0	0	0	0	0	1	0	78
Broken Islands, N	0	16	156	0	3	0	1	1	0	1	1	2	0	4	185
Broken Islands, S	0	92	115	0	10	0	2	0	0	0	2	1	2	0	224
Hemp Island	0	153	195	6	19	0	3	14	1	4	23	2	4	0	424
Tarpon Bay Keys	0	32	62	5	10	0	14	8	1	0	20	13	3	10	178
TOTAL	20	411	692	16	74	3	35	46	3	14	57	29	11	215	1626

REGIONAL WADING BIRD ABUNDANCE

EVERGLADES NATIONAL PARK AREA

Standard aerial transect counting techniques in conjunction with a systematic sampling design, better known as a Systematic Reconnaissance Flights (SRF) has been used since 1985 to document wading bird abundance, distribution and changes in hydro pattern in Everglades National Park. SRF has been, so far, the only way to survey the entire Everglades area within a reasonable amount of time and with the frequency needed in this type of study. Data obtained for over a 24-year period, suggests that wading bird populations are slowly recovering; perhaps as a consequence of the ongoing Everglades restoration efforts. Long and short term data analysis supports the importance of hydrological conditions in determining abundance and distribution of wading birds in the Everglades.

Wading birds are especially sensitive to changes in the seasonal cycles of wet and dry surface conditions (Bancroft & Jewell, 1987; Kushlan *et al*, 1975 and Russell *et al*, 2002). For this reason, wading birds have been used as indicator species in the evaluation of human impact and success of the restoration efforts in the Everglades ecosystem (DeAngelis *et al*, 1996). The data obtained during each SRF, not only provide information about the status and trends of wading bird populations in the Everglades National Park, but also information needed for modelers to select the best management options.

Methods

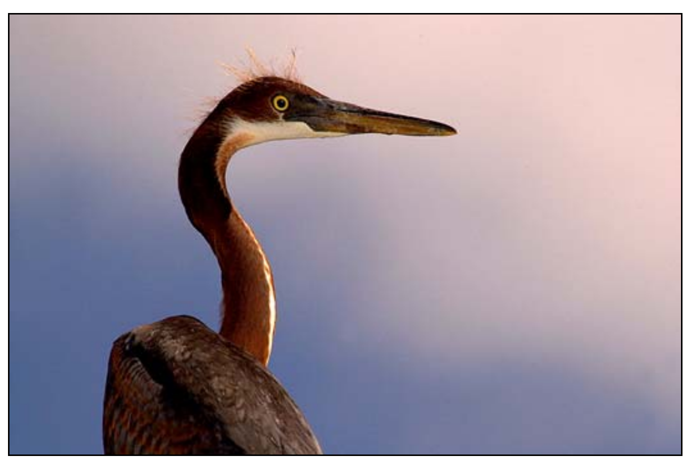
SRF is a scientific method used in wildlife surveys for assessing the distribution and abundance of wild animals (Norton-Griffiths, 1978). This particular method was adopted by Everglades National Park because it is highly cost-effective in achieving the main objectives of the Wading Bird Inventory and Monitoring program. SRF's were performed monthly, during the dry season, between Dec 2007 and May 2008 (SRF 2008). Flights were conducted over 3 to 4 consecutive days using a fixed-wing Cessna 182 at an altitude of 60 m., and at a speed between 80 to 90 knots. The area covered included mainland Everglades National Park, the zone east and southeast of the main entrance, and the southern region of Big Cypress National Preserve. The area was surveyed using transects oriented E to W and separated by 2 km (Figure 1). In 1988, transects 76 to 83 were extended to the east providing complete coverage of the area. As a result of this change, data used has been adjusted according to type of analysis performed.

Wading birds were counted, identified and geographically located using GPS units. The birds observed were classified in nine groups: white ibis, wood stork, great white heron, great blue heron, great egret, roseate spoonbill, glossy ibis, small white herons (snowy egret and cattle egret) and small dark herons (tri-colored heron, little blue heron, green heron, reddish egret, black-crowned night heron and yellow-crowned night heron).

Changes in surface water patterns (hydro-patterns) were also recorded. Five categories were used to describe the hydro-patterns: DD - absence of surface water and no groundwater visible in solution holes or ponds; WD - absence of surface water but groundwater present in solution holes or ponds; DT - ground surface area mostly dry but small scattered pools of surface water present and groundwater visible in solution holes or ponds; WT - ground surface area mostly wet but small scattered dry areas; and WW - continuous surface water over the area.

Data obtained during each SRF are compiled into a database, which contains the information collected since 1985 to the present. SRF surveys were not conducted during December 1984, December 1987 and January 1998. Missing data was estimated using the percentage of increase or decrease from month to month of years with complete data. In April 1990, May 1990 and from January 1991 to May 1991, only one observer was available for data collection during the entire SRF and during April 2004 and May 2005 few transects were missing for one observer. Densities of birds are estimated using a 2X2 Km grid. The numbers of birds counted within the 300 m stripe surveyed are extrapolated to the 4Km² cell by dividing the number of birds observed by 0.15 for surveys where data from two observers are available. In cases where only data from one observer were available the number of birds inside the 150m stripe were extrapolated to the rest of the cell by dividing the birds observed by 0.075.

For simplicity, linear regression models are used in this paper to analyze trends in the number of birds over time. The regression equation is in the form $y = bx + a$, where b is the slope or regression coefficient and a is the intercept or regression constant. Another attempt to relate surface water conditions with the relative abundance of wading birds was done using stage data available from NP-203 hydrological station. NP-203 station is located in the middle of Shark Slough. This station was selected because it's strategic location and for having one of the most complete set of records. Average stage values, from December to May, were calculated for each survey year and plotted against the estimated number of birds for that particular year. To test for a relationship between stage and wading bird abundance, a non-linear regression model (quadratic function) was used. This time the regression equation is in the form $y = ax^2 + bx + c$, where a, b and c are the quadratic, the linear and the constant coefficients respectively.



Results

Total wading bird abundance and the abundance of most wading bird species decreased during 2008 in comparison with the 2007 survey. The estimated abundance for all the species combined decreased by 29% from the 2007 to the 2008 survey. Seven of the nine species, showed a decrease in numbers from the 2007 to 2008 survey. Great white heron (GWHE) decreased by 51%; followed by small dark herons (SMDH) with 43%, great egrets (GREG) and white ibis (WHIB) with 32% each one, wood stork (WOST) with 31%, small white heron (SMWH) with 14%, and glossy ibis (GLIB) with 11% decrease. Two species, roseate spoonbill (ROSP) and great blue herons (GBHE), increased in abundance by 40% and 17% respectively from 2007 to 2008.

This year represents the first decline in abundance for all the species combined, after three consecutive years of increases. Despite the large reduction in the number of birds observed this year, the overall trend from 1985 to present still showing a significant increase, based on the linear regression model (R^2=0.234, P=0.017; Figure 2). Despite the annual fluctuations observed for each species (Figure 3), a general increase was observed in five of the nine species. Those species are in order of significance; GREG (R^2=0.411, P=0.001), GBHE (R^2=0.157, P=0.055), SMWH (R^2=0.123, P=0.092), WOST (R^2=0.113, P=0.108) and WHIB (R^2=0.095, P=0.142).

This is the first year that a decline in the number of GREG was observed after five consecutive years of increasing numbers since 2003. The numbers of WHIB, SMWH and WOST, which have shown successive increases since 2005, also declined this year. GBHE is the only that showed continuous increases since 2004. Three species, ROSP (R^2=0.030, P=0.419), GLIB (R^2=0.008, P=0.677) and SMDH (R^2=0.005, P=0.738), have remained more or less constant in the number of individuals throughout the study period. Despite these overall tendencies, the estimated numbers of SMDH have declined during the past four years, while numbers of GLIB have decline for the past three years. ROSP numbers, which declined during the last couple of years, showed an increase this year. Finally, GWHE is the only species that displayed an overall significant decline in the number of individuals observed (R^2=0.353, P=0.002), after increases during the previous two years.

Figure 1. Map of ENP and southern Big Cypress National Preserve with sampling transects and drainage basins.

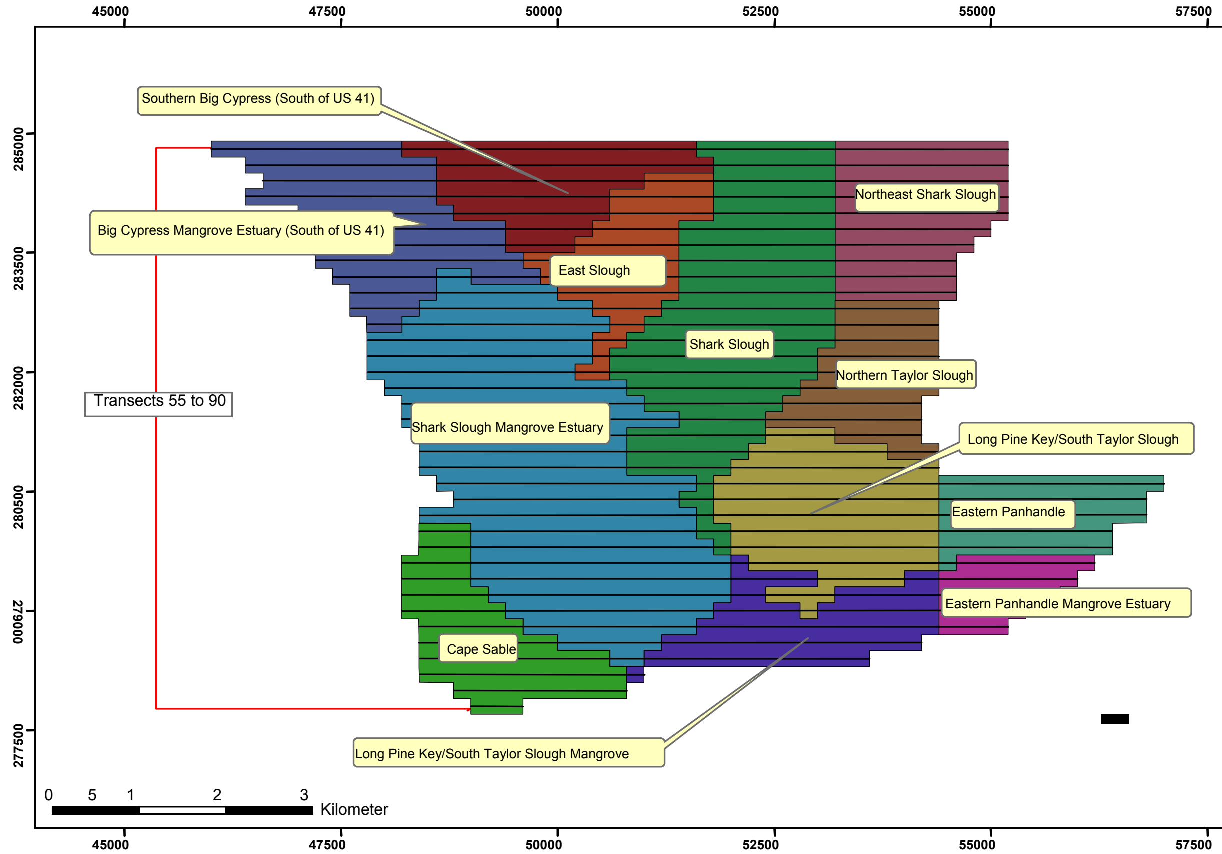


Figure 2. Estimated number of wading birds (all species pooled) observed from the months of Dec-May from 1985 to 2008. Red marks represent years with estimated missing data for one month.

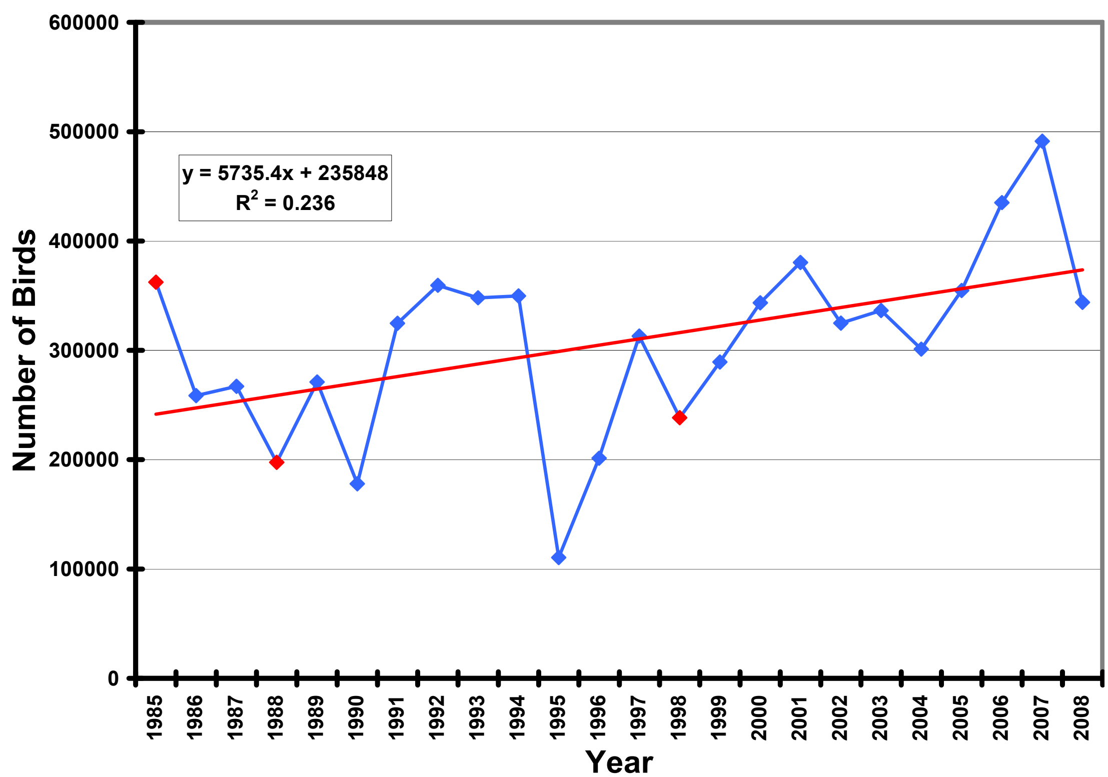
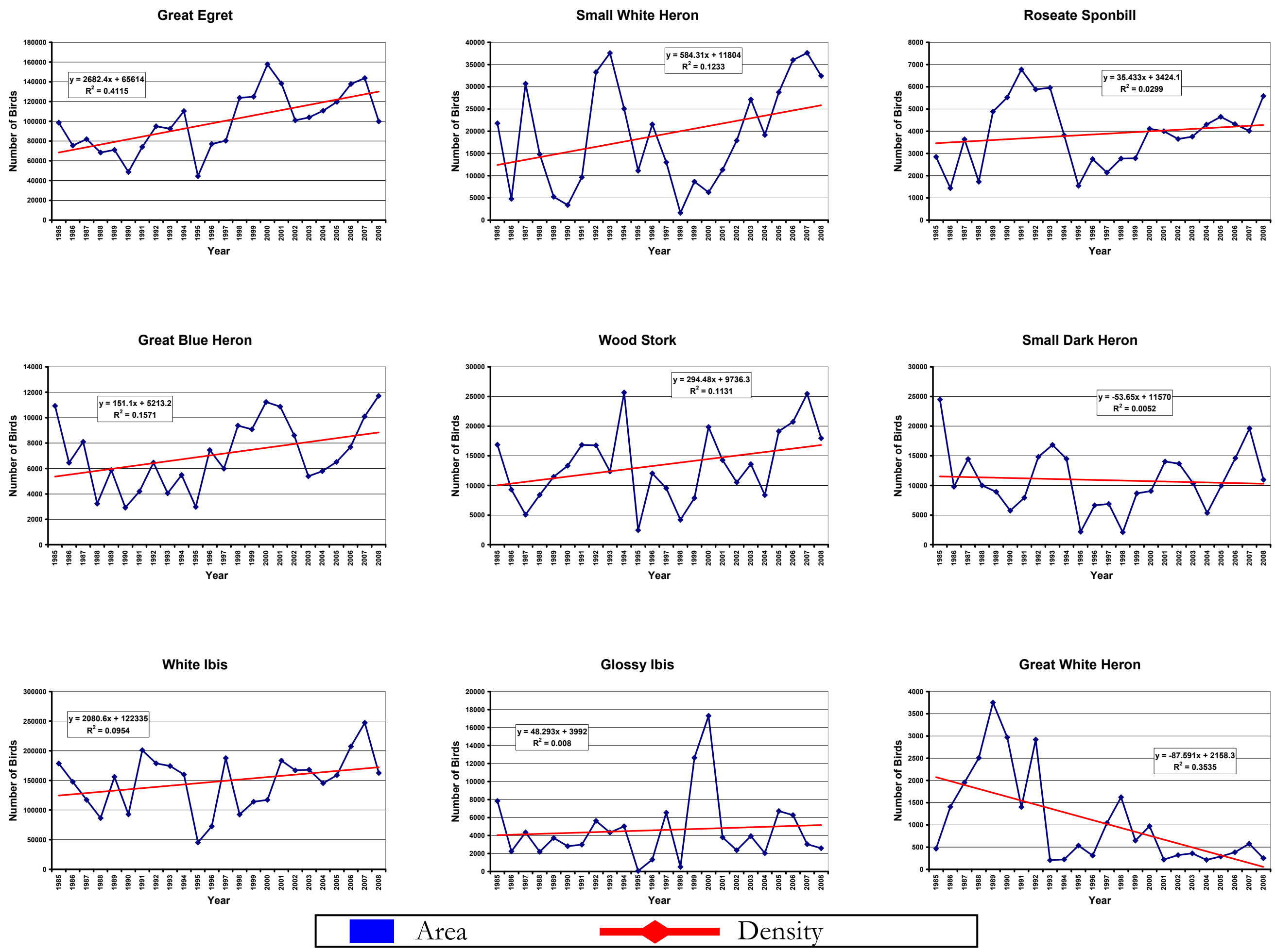


Figure 3. General trends in wading bird populations based on the total number of birds estimated during the surveys performed each year in the Everglades National Park from 1985 to the present.



During the 2008 survey, the maximum number of birds, regardless of the species, occurred in December and gradually decreased until February followed by an abrupt decline during the last two months (Table 1). It was also from December to February that the highest numbers of the most abundant species, GREG and WHIB, were observed. GBHE and SMDH showed peak abundance during those months, extending into March. Other species such as WOST and GWHE started peaking from January to February and from January to March respectively. SMWH numbers showed two distinct abundance peaks; one in December and the other in March. Finally, the richest number of birds occurred in February for GLIB and in March for ROSP. April and May had the lowest number of birds for all the species combined. Six of the nine species showed the lowest numbers in May; while the other three species lowest numbers were observed in April. The most abundant species this year was WHIB with 47% of the total number of birds observed, followed by GREG with 29%. These two species combined accounted for more than 75% of the total number of birds recorded for this year. The remaining 25% was consisted of SMWH (10%), WOST (4%), GBHE and SMDH (3% each one), ROSP (3%), GLIB (1%), and GWHE (less than 1%).

Differences in the distribution and abundance of wading birds were observed among drainage basins (Table 2). Shark Slough (SS) contained the highest number of wading birds (20%), followed by Shark Slough Mangrove Estuary (SSME) with 18%. These two basins accounted for 38% of the total of birds observed this year. A substantial number of basins with intermediate values were also observed this year; Cape Sable (CS) with 11%, Big Cypress Mangrove Estuary (BCME) and Southern Big Cypress with 10% each one, and East Slough and Northeast Shark Slough with 9% a piece. These five basins with intermediate values, made up close to fifty percent of the total of birds observed during the season. In contrast; the basins with the lower number of birds were Northern Taylor Slough (NTS) with less than 1%, Eastern Panhandle Mangrove Estuary (EPME) with 1% and Eastern Panhandle (EP) with 4%. A great concentration of birds was observed during December at CS and SSME in relation to the other basins. During December, 42% of the total number of birds were found at these two basins. In January, the highest concentrations of birds were observed at SSME; accounting for 27% of the total birds for this month. By the months of February and March, most of the birds were found in SS. During the last two months, birds were spread almost evenly system wide; with a slight higher concentration at BCME by the end of the season. Two basins (NTS and EPME) showed very low concentrations of birds during the last two months.

Densities of birds were also different among the basins as the 2008 survey progressed from December 2007-May 2008 (Figure 4). Higher densities of birds were observed this year, at the beginning of the season, at most of the coastal basins (CS, SSME, EPME and BCME), as well as in the intermediate elevation basin of ES. By the middle of the season, as water recedes, foraging birds distributed system wide with especial high concentrations at SBC, NESS, and EP. The few birds that remained in the Everglades at the end of the season were found foraging mostly at the coastal basins (BCME, SSME, LPK/STSME, EP and CS). High elevation basins such as NTS and LPK/STS showed very low densities throughout the season.

Changes in hydro-patterns and bird distribution observed this season (Figure 5) were very similar of those observed in the previous year (see Alvarado & Bass, 2007). The greatest changes in the area covered by the different hydro-patterns during the 2007 survey took place at the extreme categories (WW or DD). From December to May, the original extend of the area covered by WW was reduced from 30% to 13% (856 Km^2 reduction), while DD area experienced an increase going from 9% at the beginning of the season to 31% at the end of the season (1,076 Km^2 increase). Intermediate categories such as WT and WD showed very slight changes throughout the season. The areal extend for WT decreased from 35% to 28% (344Km^2), while WD increased from 11% to 14% (140 Km^2). Finally, very small fluctuations occurred in the middle category, DT during the survey, with no more than 4% change at the most from month to month. Despite the magnitude of these changes, they occurred gradually from December to March. However, this pattern was disrupted on April by a series of rain events that occurred at the end of March and beginning of April.

Table 1. Estimated abundance of wading birds in the Everglades National Park and adjacent areas, Dec 2007- May 2008.

Species	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Total
GREG	24,583	19,329	23,388	20,438	7,561	7,087	102,386
GBHE	2,606	3,219	2,666	2,223	749	708	12,171
SMDH	2,080	1,924	2,476	3,405	880	799	11,564
SMWH	9,399	7,251	5,077	8,112	1,616	2,795	34,250
WHIB	40,558	44,538	40,685	30,554	6,327	5,587	168,249
GLIB	394	427	946	451	273	101	2,592
WOST	2,645	4,318	4,964	1,452	522	679	14,580
ROSP	1,275	506	947	5,242	933	520	9,423
GWHE	28	63	63	63	35	21	273
TOTAL	83,568	81,575	81,212	71,940	18,896	18,297	355,488

GREG = great egret, GBHE = great blue heron, SMDH = small dark herons (tri-colored heron, little blue heron, green heron, reddish egret, black-crowned night heron, yellow-crowned night heron, American bittern and least), SMWH = small white herons (snowy egret and cattle egret), WHIB = white ibis, GLIB = glossy ibis, WOST = wood stork, ROSP = roseate spoonbill, GWHE = great white heron

Table 2. Estimated abundance of wading birds (all species combined) for the different drainage basins in the Everglades National Park, Dec 2007 – May 2008.

Month	SBC	BCME	SS	NESS	ES	SSME	NTS	LPK/ STS	EP	CS	LPK/ STSM	EPME	Total
Dec	10,324	9,918	6,277	3,066	6,163	17,116	606	1,039	6,316	17,835	2,725	2,183	83,568
Jan	7,577	9,412	10,790	7,305	8,507	21,813	369	1,953	2,173	7,514	2,736	1,426	81,575
Feb	7,119	5,738	22,030	14,034	10,253	10,382	7	2,562	858	4,495	3,146	588	81,212
Mar	4,737	5,760	26,601	6,576	2,964	10,225	0	1,339	2,506	4,788	5,982	462	71,940
Apr	1,819	1,423	3,392	641	2,383	2,292	34	1,567	1,058	2,147	2,071	69	18,896
May	2,259	3,009	1,815	404	2,152	1,338	0	2,513	122	1,878	2,793	14	18,297
Total	33,835	35,260	70,905	32,026	32,422	63,166	1,016	10,973	13,033	38,657	19,453	4,742	355,488

SBC = Southern Big Cypress (South of US 41), BCME= Big Cypress Mangrove Estuary (South of US 41), SS= Shark Slough, NESS = Northeast Shark Slough, ES = East Slough, SSME = Shark Slough Mangrove Estuary, NTS = Northern Taylor Slough, LPK/STS = Long Pine Key / South Taylor Slough, EP = Eastern Panhandle, CS = Cape Sable, LPK/STSM = Long Pine Key / South Taylor Slough Mangrove Estuary, EPME = Eastern Panhandle Mangrove Estuary

Figure 4. Spatial and temporal changes in wading bird density among the different drainage basins between Dec-07 and May-08.

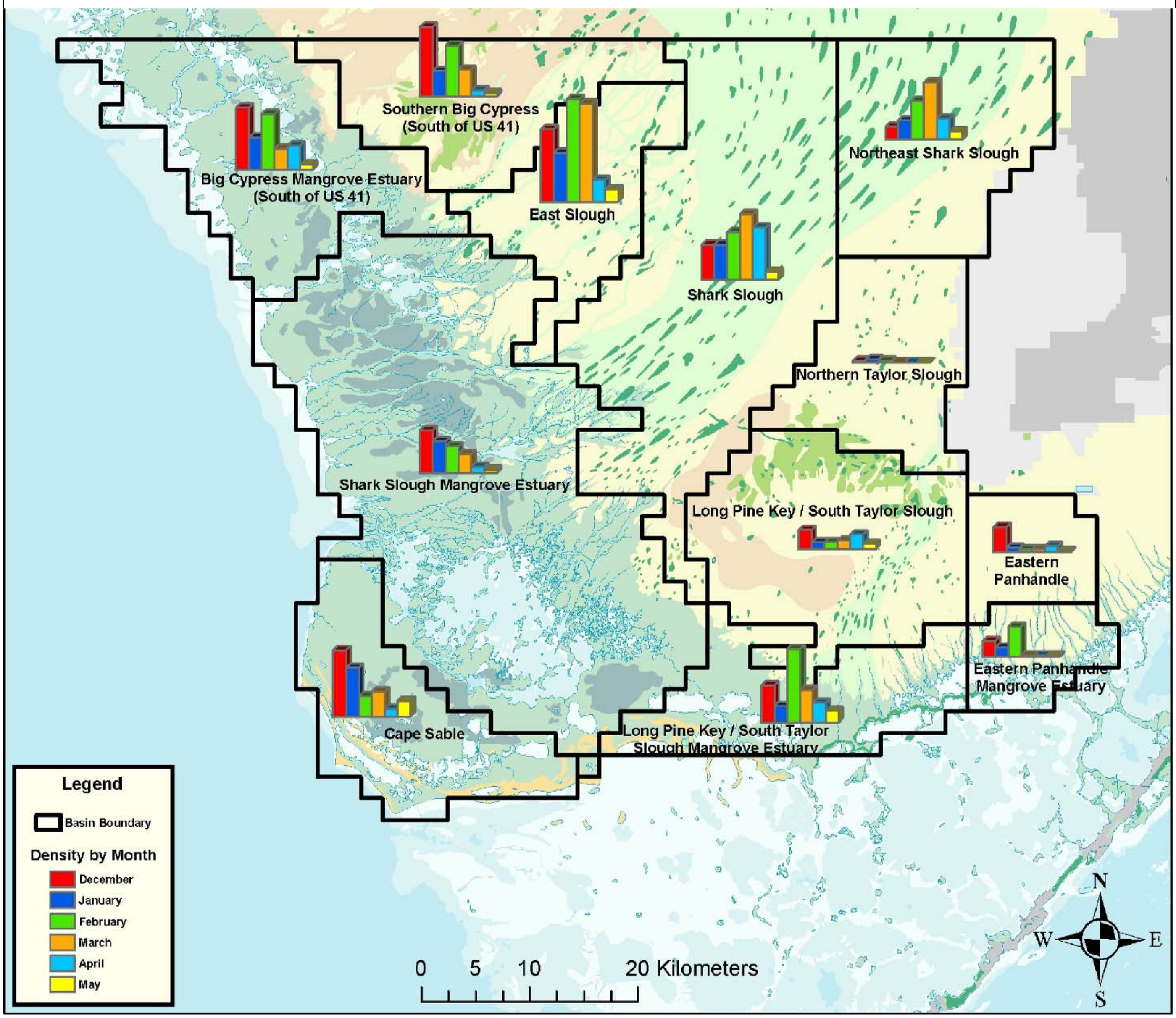
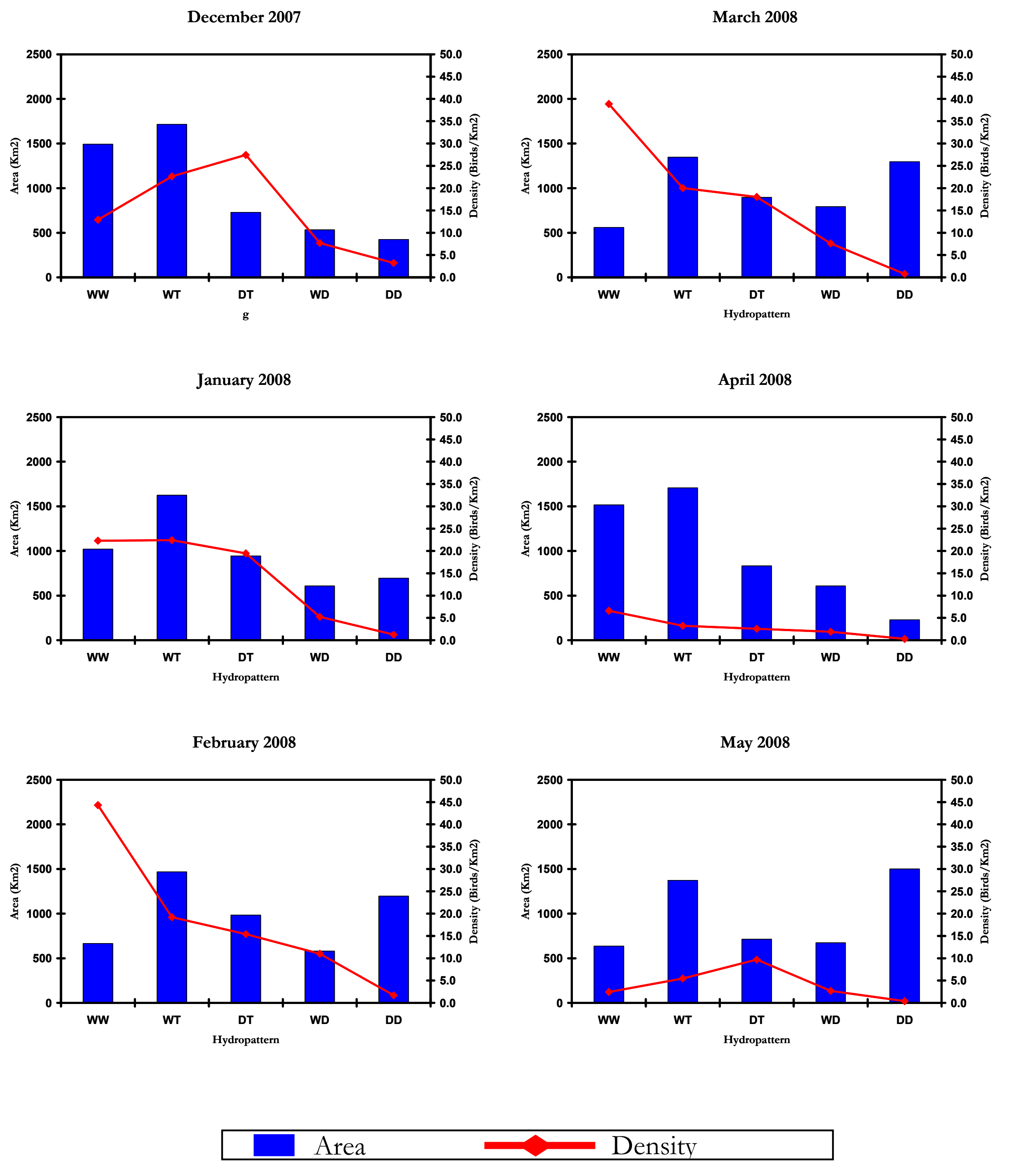
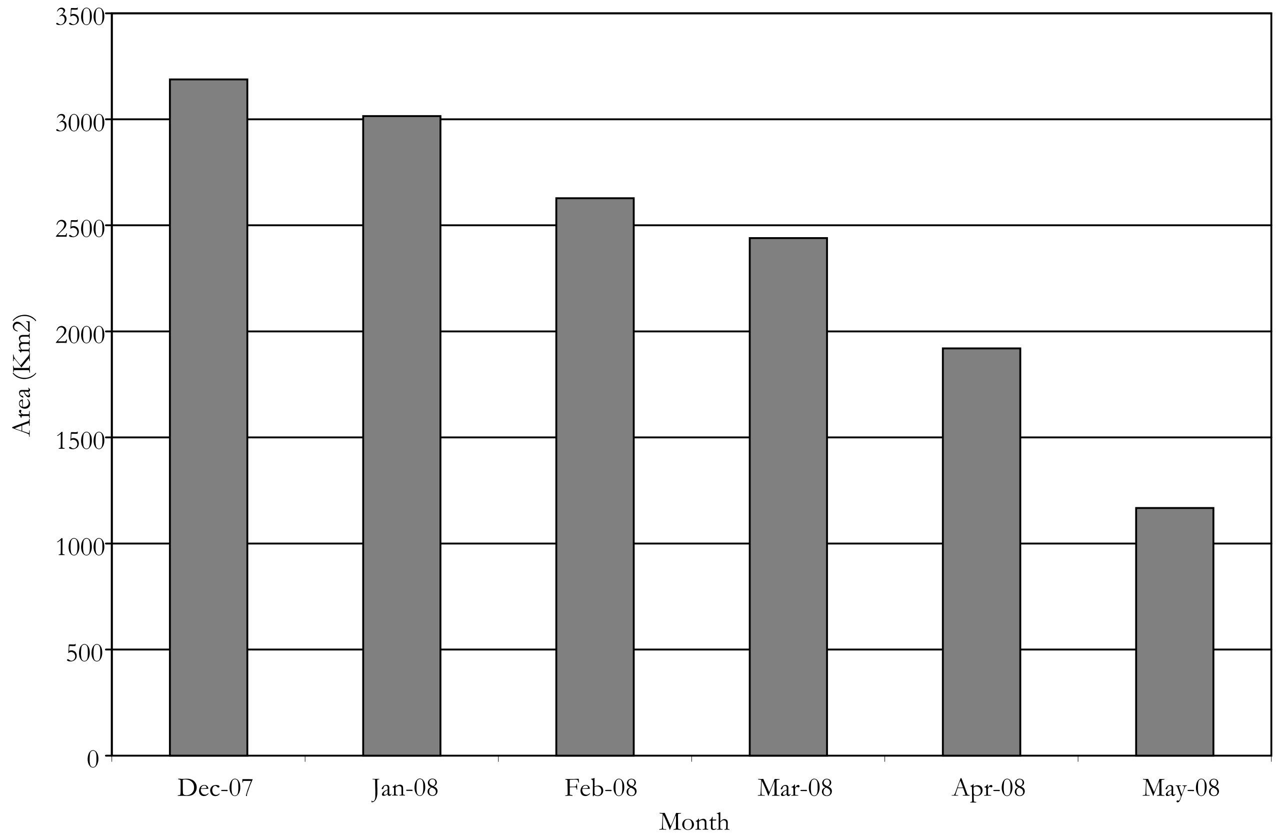


Figure 5. The 2008 areal extent and density of wading birds (all species pooled) in each surface water category.



WW = continuous surface water; WT = mostly wet with scattered dry areas; DT = mostly dry with small scattered pools of water; WD = dry with water only in solution holes; DD = dry surface.

Figure 6. Monthly changes in wading bird areal utilization in the Everglades National Park from Dec-2007 to May-2008.



During the month of December, the highest densities of birds were observed mainly in the DT and WT categories, respectively. By January, as water receded, the density of birds foraging in WW areas almost doubled, while at the same time the density of birds at DT declined 29%. Water levels continued receding until March, producing consequently high densities of birds at WW areas. During these months, very little changes in bird density were observed in the other hydro-patterns. Major rain events occurred between the end of March and the beginning of April that reversed the water receding trend observed until then. Despite the increase in water coverage observed in April, densities of birds were very low during the last two months. At the end of the season, the highest density of birds was located in DT.

The spatial use of Everglades National Park and Southern Big Cypress National Preserve by wading birds decreased as the 2008 survey progressed. Birds were found foraging in approximately 65% of the study area during the month of December and in 62% during January (Figure 6). By February and March, birds were occupying an area slightly larger than half of the study area. April and May were the months with the smallest area used by birds with only 39% and 24% respectively of the total available area.

Stage values and numbers of estimated birds showed clearly that wading birds are less abundant during extreme water conditions (Figure 7). During 1995, a particularly wet year, the number of birds was the lowest of the entire period of records. In the other hand, in 1990, a very dry year, the number of birds was also low. A quadratic function model (Figure 8) was used to analyze this type of behavior where too much or too little water in the system can lead to drastic changes in wading bird abundance. A significant relationship was found between the number of birds observed and the average stage at the NP-203 (R^2=0.453, P=0.002). This curve also suggests that optimal stage values, using NP-203 station as a reference, for wading bird abundance could be somewhere around 1.77 m.

Figure 7. Relationship between numbers of birds observed for every year since 1985 to 2008 and the stage elevation in meters at the NP-203 hydrological station.

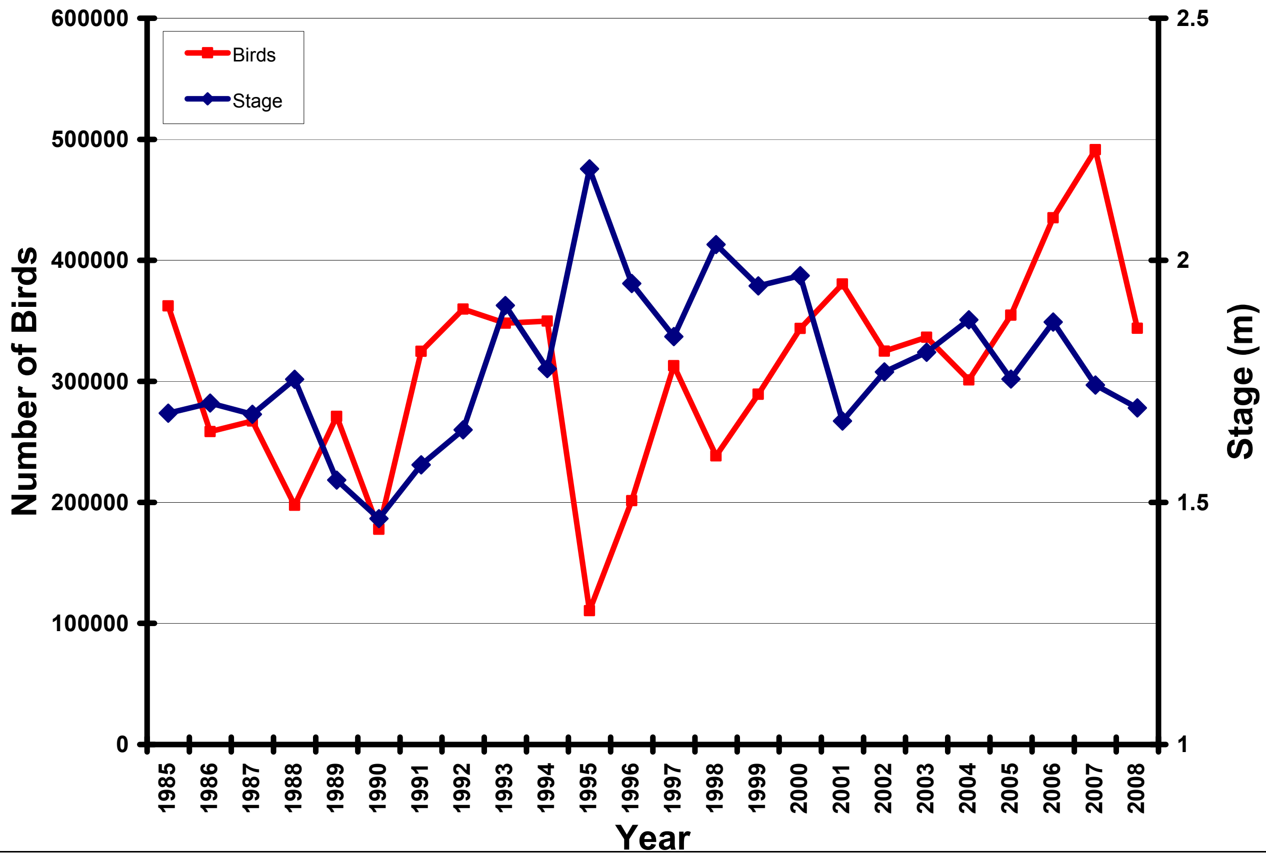
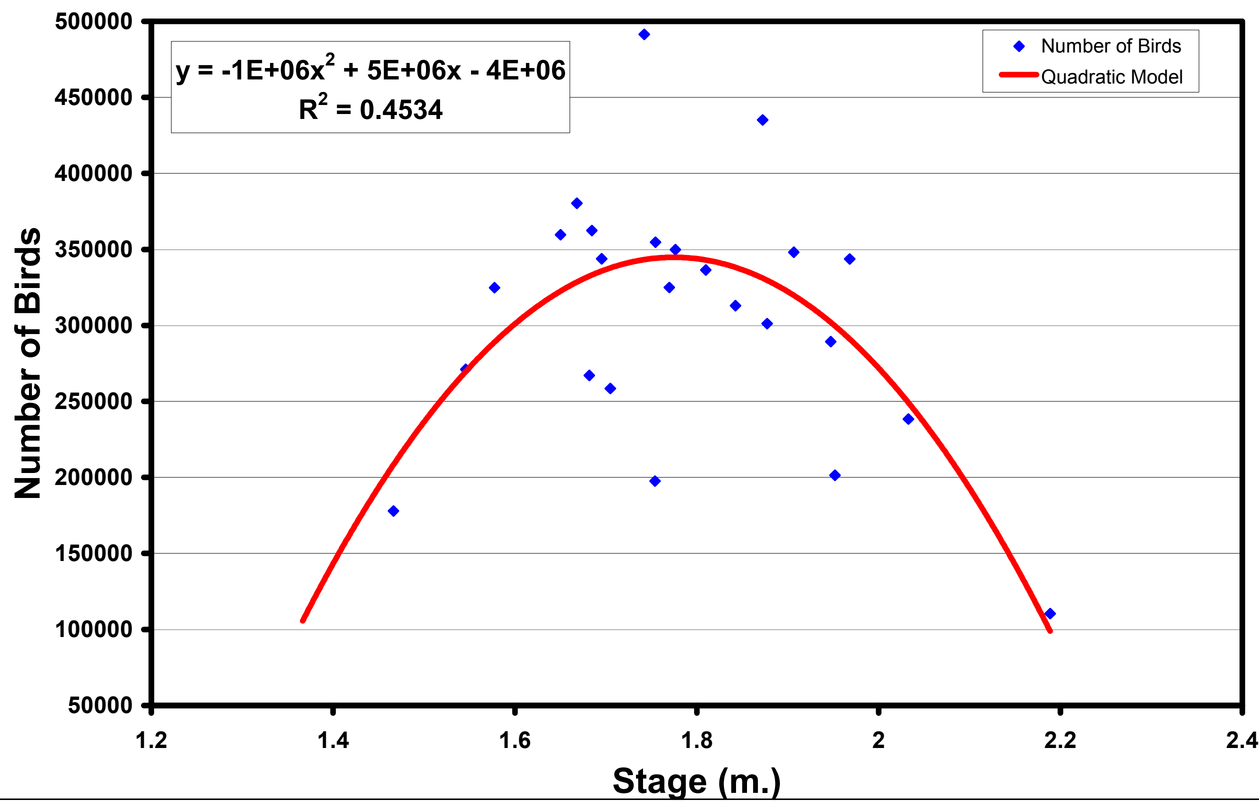


Figure 8. Quadratic function model used to test the relationship between wading bird abundance and average stage height using the NP-203 hydrological station data.



Discussion:

The population of wading birds within the Everglades has decreased between 70 and 90% since the 1930's (Bancroft, 1989; Ogden, 1994). This reduction in the numbers of wading birds has been directly linked at the beginning to unregulated hunting and illegal poaching, and lately to the human alteration of the Everglades natural hydrology. Because these birds are very sensitive to changes in hydrology, they have been used as indicators to measure the Everglades restoration success.

Everglade's populations of wading birds in general, based on SRF data over a 24-year period, give the impression of an overall significant increase. This year represents the first season where a decline in the number of birds has been observed after three years of consecutive increases. Most species have shown a trend to increase or to maintain overall stable populations. Unfortunately for GWHE, that is not the case. Despite the increases observed from 2005 to 2007, the overall trend shows a significant population decrease. This significance was reinforced by the low number of GWHE observed this year. The increase observed during the previous three years in wading bird populations, suggest that the ongoing restoration efforts, are improving the habitat conditions for wading birds species and perhaps for many other organisms that reside permanently or temporarily in the Everglades. However those efforts could be masked by natural factors such as droughts. Based on rainfall and stage data obtained at the hydro-station NP203, the 2008 wading bird season could be considered as a dry year. Although this preliminary analysis can provide some general ideas of the trends in the number of individuals observed for each species or groups of birds through the years, additional studies and more data analysis will be necessary in order to evaluate the significance of these observations and its relevance to the wading bird populations occurring in the Everglades National Park.

Wading bird populations in the Everglades are dynamic, changing constantly, and are influenced by many factors (Russell *et al*.., 2002). However, the most influential aspect is perhaps habitat alteration; particularly those involving interference with the natural hydrological conditions. Food availability has been consider the most important factor limiting populations of wading birds in the Everglades (Frederick and Spalding, 1994), and hydrologic conditions ultimately determines the availability of food.

During normal water budget conditions years, water goes from high levels, at the beginning of the season, to dryer conditions or receding water levels at the end of the season. As water recedes, later in the season, birds began to concentrate in those areas that have the right water levels, turning these areas into new foraging territories. At the end of the season, great numbers of birds leave the system for areas with longer hydro-period and better foraging conditions such as the Water Conservation Areas (Cook and Herring, 2007).

Based on the annual precipitation obtained at the NP-203 hydro-station, the 2008 season is considered dryer than normal, despite the increase of 19.5 cm of rainfall obtained this year. The total precipitation recorded this year was 9.6 cm below the average rainfall for this station. Rainfall deficits have been recorded during the last couple of years. SRF data are collected during the dry season (Dec-07 to May-08), and total precipitation data from the previous year is probably the best indicator of the amount of water in the system during the survey. Average stage between December and May was also 10.9 cm lower than the one obtained during the previous year at the same hydro-station. This lack of water and consequent reduced food supply is probably the main cause of the reduction in the number of birds observed this year, as well as their early widespread distribution.

Data obtained during each SRF over the years, as well as the one obtained during the 2008 survey support the important roll that right hydrological conditions plays on the abundance and distributions of wading bird populations in the Everglades. The concept of too much/too little or just the right amount of water as well as the too late/too early or just at the right time seem to be of particular importance for wading birds.

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WADING BIRD SURVEYS FOR WATER CONSERVATION AREAS AND BIG CYPRESS NATIONAL PRESERVE

Methods

Wading bird surveys were flown with a fixed wing aircraft at an altitude of about 60 meters along parallel transects with 2-km spacing each month from January to June 2008. Wading birds were identified to species when possible, enumerated, their locations recorded, their data entered into a database, and summarized into tables. Densities of each species were separated into 4-km2 cells and plotted onto maps. Data were recorded using HP720 palm top computers linked to GPS.

Results

In the Water Conservation Areas, monthly wading bird relative abundance was lower during 2008 than 2007. In the Water Conservation Areas, the maximum relative abundance was observed during January 2008 (82,420) and during June 2008 (87,287). In 2008, February, March and April relative abundances were lower than the same months in 2007. The wading bird abundances in January 2008 and June 2008 were higher than the respective months in 2007. During 2008, water levels in the Water Conservation Areas remained wet but declined from January to May then increased in June. In the Big Cypress National Preserve, monthly wading bird abundances were lower in 2008 than 2007. The maximum relative abundance was observed during January 2008 (18,853). In the Big Cypress National Preserve, monthly wading bird abundance peaked in January 2008 then declined until June 2008 in response to very dry conditions. Final reports from 1996 to 2007 are currently available.

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Table 1. Water Conservation Areas wading bird estimated abundance, 2008.

Species	Jan	Feb	Mar	Apr	May	Jun
GREG	29,347	25,093	26,247	16,353	20,900	42,627
GBHE	553	913	553	513	593	447
SMDH	260	493	480	160	93	167
SMWH	780	7	313	167	253	493
WHIB	47,567	23,153	32,647	11,713	17,760	39,314
GLIB	387	407	367	93	27	60
WOST	667	1680	360	120	253	800
ROSP	87	213	27	187	140	473
GWHE	2,773	3,900	3,380	2,540	2,007	2,907
Totals	82,420	55,860	64,374	31,847	42,027	87,287

Table 2. Big Cypress National Preserve wading bird estimated abundance, 2008.

Species	Jan	Feb	Mar	Apr	Jun	Jul
GREG	10,133	6,220	4,940	2,807	2,020	887
GBHE	107	140	100	27	20	0
SMDH	20	67	7	0	0	13
SMWH	173	267	53	67	67	47
WHIB	7,367	4,713	3,847	1,707	500	73
GLIB	0	0	0	33	0	0
WOST	600	820	120	193	380	160
ROSP	0	0	0	0	0	0
GWHE	453	627	733	433	213	120
Totals	18,853	12,853	9,800	5,267	3,200	1,300

STATUS OF WADING BIRD RECOVERY

The sustainability of healthy wading bird populations is a primary goal of CERP and other Everglades restoration programs in south Florida. The central prediction of CERP is that a return to natural flows and hydropatterns will result in the recovery of large, sustainable breeding wading bird populations; a return to natural timing of nesting; and restoration of large nesting colonies in the coastal zone. As the science branch of CERP, RECOVER established Performance Measures (PM) for tracking the ecological progress of these breeding and nesting parameters (http://www.evergladesplan.org/pm/recover). The purpose of this report is to summarize the annual nesting patterns of wading birds in the context of these performance measures indices and those associated goals and targets, while the RECOVER System Status Reports (RECOVER 2006, 2007) presents the analysis of the Greater Everglades Wetlands module predator-prey hypothesis cluster that integrates the hydrology, aquatic prey and wading bird nesting results. The main indicator species are Great Egret, Snowy Egret, Tricolored Heron, White Ibis, and Wood Stork. These data are reported for the three Water Conservation Areas and mainland Everglades National Park. The following results summarize the 2008 colony surveys and an update of a 3-year running average for numbers of nesting pairs (Table 1).

Table 1. Three year running averages of the number of nesting paris for the five indicator species in the Everglades.

Time Period	GREG	SNEG/ TRHE	WHIB	WOST
Target minima	4,000	10,000 to 20,000	10,000 to 25,000	1,500 to 2,500
1986-88	1,946	2,057	2,974	175
1987-89	1,980	1,680	2,676	255
1988-90	1,640	1,229	3,433	276
1989-91	1,163	903	3,066	276
1990-92	2,112	1,965	8,020	294
1991-93	2,924	2,792	6,162	250
1992-94	3,677	2,939	6,511	277
1993-95	3,843	2,060	2,107	130
1994-96	4,043	1,508	2,172	343
1995-97	4,302	1,488	2,850	283
1996-98	4,017	1,334	2,270	228
1997-99	5,084	1,862	5,100	279
1998-00	5,544	2,788	11,270	863
1999-01	5,996	4,270	16,555	1,538
2000-02	7,276	8,614	23,983	1,868
2001-03	8,460	8,088	20,758	1,596
2002-04	9,656	8,079	24,947	1,191
2003-05	7,829	4,085	20,993	742
2004-06	8,296	6,410	24,926	800
2005-07	6,600	4400*	21,133	633
2006-08	5,869	3,778	17,541	552

*Tricolored Herons are excluded from this total due to incomplete surveys for this species in 2007.

Results

Numbers of Pairs

The 2008 combined total of nesting pairs for the five indicator species was 11,123 pairs, divided as follows: 2,263 pairs of Great Egrets, 859 pairs of Snowy Egrets, 169 pairs of Tricolored Herons, 7,782 pairs of White Ibis, and zero pairs Wood Storks. The three year running average for 2006-2008 for the four groups are 5,869 for Greater Egrets, 3,778 for Snowy Egrets and Tricolored Herons, 17,541 for White Ibis, and 552 for Wood Storks. Ogden et al. (1997) recommends utilizing a 3-year running average for assessing recovery trends. The 3-year running average has been declining for all wading bird indicator groups during the past three years.

Colony Locations

Less than 7% of the combined total for these five indicator species nested in the region of the southern Everglades marsh/mangrove ecotone, including the southern mainland mangrove estuary. It is estimated that more than 90% of the nesting of these five species occurred in this southern ecotone region during the 1930s and early 1940s and averaged 26% during the baseline period of 1986 – 1995 that was used to establish the performance measures and targets.

Timing of Nesting

This parameter applies only to the initiation of nesting for Wood Storks, which has shifted from November through December to January through March. This shift increases the risk of mortality of nestlings that have not fledged prior to the onset of the wet season and was the direct cause of the unsuccessful 2008 Wood Stork nesting season. Wood Storks nesting had only a few starts in February 2008 with most of the nesting occurring in early March. However, all nests were abandoned in April following significant rain events.

Discussion

Performance Measures GE 20 (Wetland Trophic Relationships – Wading Bird Foraging Patterns on Overdrained Wetlands) and GE-21 (Wetland Trophic Relationships – Wading Bird Nesting Patterns) specifically address the ecological premise that the collapse of the wading bird nesting colonies in the southern Everglades is attributed to declines in population densities and season concentration of marsh fishes and other aquatic prey organisms as well as annual recession rates that directly affect nesting success rates. It is expected that a restoration of natural hydrologic conditions will re-establish distributions of prey densities and concentrations across the landscape, which will in turn support the return of large, successful wading bird nesting colonies to the southern Everglades.

Ogden et al. (1997) first proposed the establishment of specific restoration targets for mainland nesting patterns by the general population of wading birds and specifically for Wood Storks. This included the recommendation of target minima for the number of nesting pairs in mainland colonies of 4,000 pairs of Great Egrets, 10000 to 20,000 combined pairs of Snowy Egrets and Tricolored Herons, 10,000 to 25,000 pairs of White Ibis, and 15,000 to 2,500 of Wood Storks. It also targeted an increase in the proportion of nests south of Tamiami Trail to greater than 50% of the total for the entire Everglades basin.

Since 1994 the 3-year running average of the number of Greater Egret nesting pairs has exceeded the 4,000 pair established minima (Table 1) and was steadily increasing until 2004, with 2002 being a notable year for most of the indicator species. The combined nesting counts for Snowy Egrets and Tricolored Herons have yet to reach the 3-year minima of 10,000 nesting pairs, but also responded with record nesting pair counts in 2002. White Ibis running average nest counts reached and maintained the 10,000 count minima and until this year were trending toward the upper end of 25,000 nesting pairs. The Wood Storks have barely reached the minima of 1,500 nesting pairs for three consecutive years from 2001 to 2003, but has generally been declining since 2003.

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SPECIAL TOPICS

A FIRST FOR CORKSCREW'S WOOD STORK COLONY

Audubon began recording the wood stork nesting effort at Corkscrew Swamp Sanctuary in 1958, and the storks have attempted nesting in 41 of the 50 years. This year has the unfortunate distinction of marking the first time on record that wood storks failed to nest for two consecutive years at Corkscrew.

During the nesting season, Corkscrew's wood storks rely heavily on freshwater wetlands for foraging. The colony forms in the tops of large old growth bald cypress trees in the Corkscrew watershed. This deep natural cypress slough provides an ideal setting for late season foraging when chicks are large, or have recently fledged. Early in the nesting season however, the storks exploit shallow foraging areas associated with short hydroperiod wetlands. Natural freshwater wetlands spread out in all directions from the colony, but massive land use changes have dramatically altered the foraging landscape for tactile feeders like wood storks. Starting in the early 1930's, an extensive network of ditches and canals altered the hydrologic regime across hundreds of thousands of acres of wetlands to accommodate growth. Vast areas were either drained or impounded.

Historically wood storks began nesting in Corkscrew sometime in November or December. However, by the late 1970's the wood storks nesting at Corkscrew began to delay their nest initiation until January and February. This shift in nest initiation lags well behind an evident and dramatic decline in the colony's productivity which was evident by the mid 1960's[A]. These declines are widely considered to be a result of the loss of foraging habitat. Comparisons of the Pre-development Map of Southwest Florida (Fig. 2) with the 2004 Land Use Map (Fig. 3) clearly illustrate a disproportionate reduction in shallow, short-hydroperiod wetlands. These wetlands provide foraging resources for wood storks early in the year. Loss of these wetlands can explain the shift in nest initiation. With fewer natural shallow wetlands available for foraging, wood storks are often observed foraging in altered sites such as roadside ditches and agricultural fields (Fig. 4). Typically by February the dry-down has progressed enough to concentrate fish in the deeper pools of the remaining long hydroperiod natural wetlands which are found in much greater proportion compared to shallow wetlands (Fig. 5).

While projects aimed at restoring the Western Everglades hold the promise of benefiting wood storks nesting at Corkscrew, there is still considerable uncertainty about the future of this historic colony. Once the largest most consistent stork colony in the Nation, Corkscrew has become unstable and inconsistent. Despite the economic downturn, development is still a concern. The conversion of shallow wetlands still occurs, and mitigation for those lost acres is often done in deeper wetlands, or is paid for via a functional lift resulting from exotics removal. Removal of exotics is a good endeavor, and it will provide some benefits for wading birds and other wildlife. But only time will tell if this practice is indeed sufficient to offset the dwindling pool of short hydroperiod wetland acres that remain to support the wood storks in Southwest Florida from October through mid-January.

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Figure 1. Rainy season rainfall recorded at the Corkscrew Swamp Visitor Center is shown in comparison with the 48 year average of 37 inches. The nine rainy seasons preceding the years wood storks did not attempt to nest at Corkscrew are indicated with black bars.

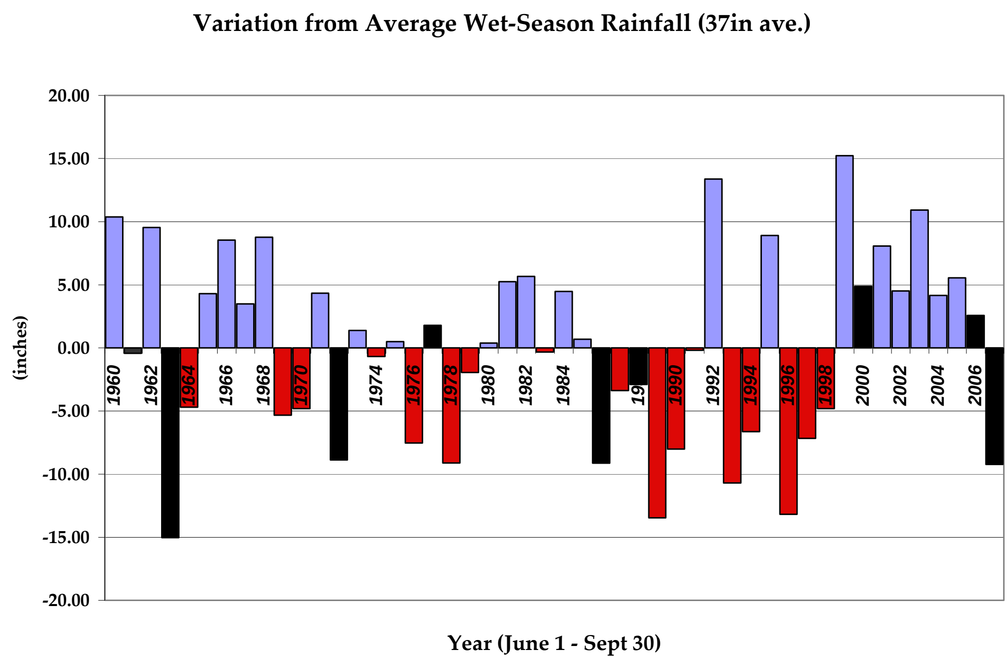


Figure 2. This version of the pre-development map was created using the ARCGIS data set developed through the Southwest Florida Feasibility study. The primary architect for the data set is Dr. Mike Duever. The division between a short hydroperiod (pinks) and long hydroperiod (greens) wetland occurs at 180 days. Uplands are depicted in shades of brown.

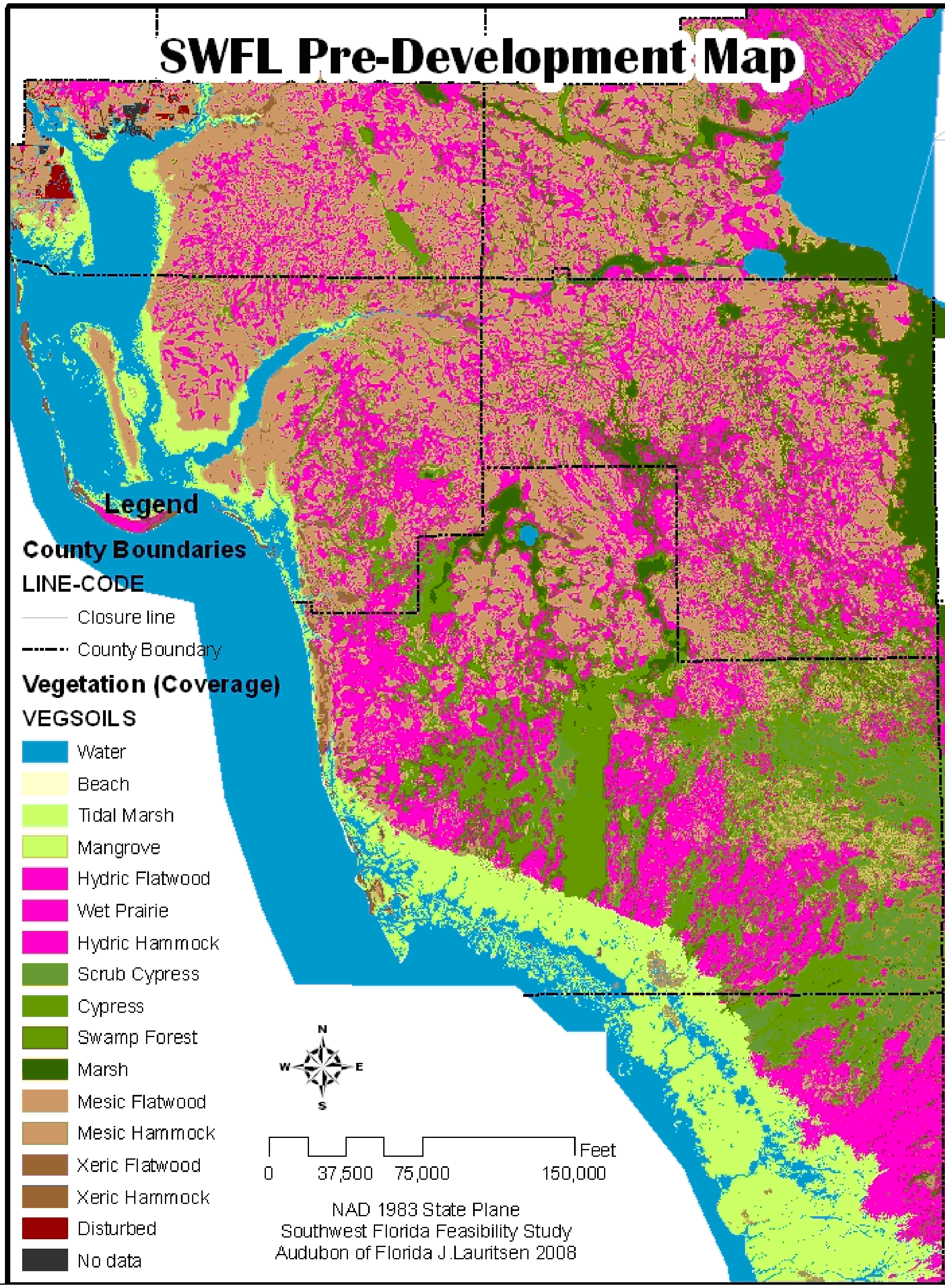


Figure 3. This map was created using the ARCGIS data set from the South Florida Water Management District's 2004 Land Use Map. In addition to the pinks, greens and browns consistent with the pre-development map, this map depicts pastures in shades of orange, citrus and row crops in shades of yellow, and the built environment in reds and grays.

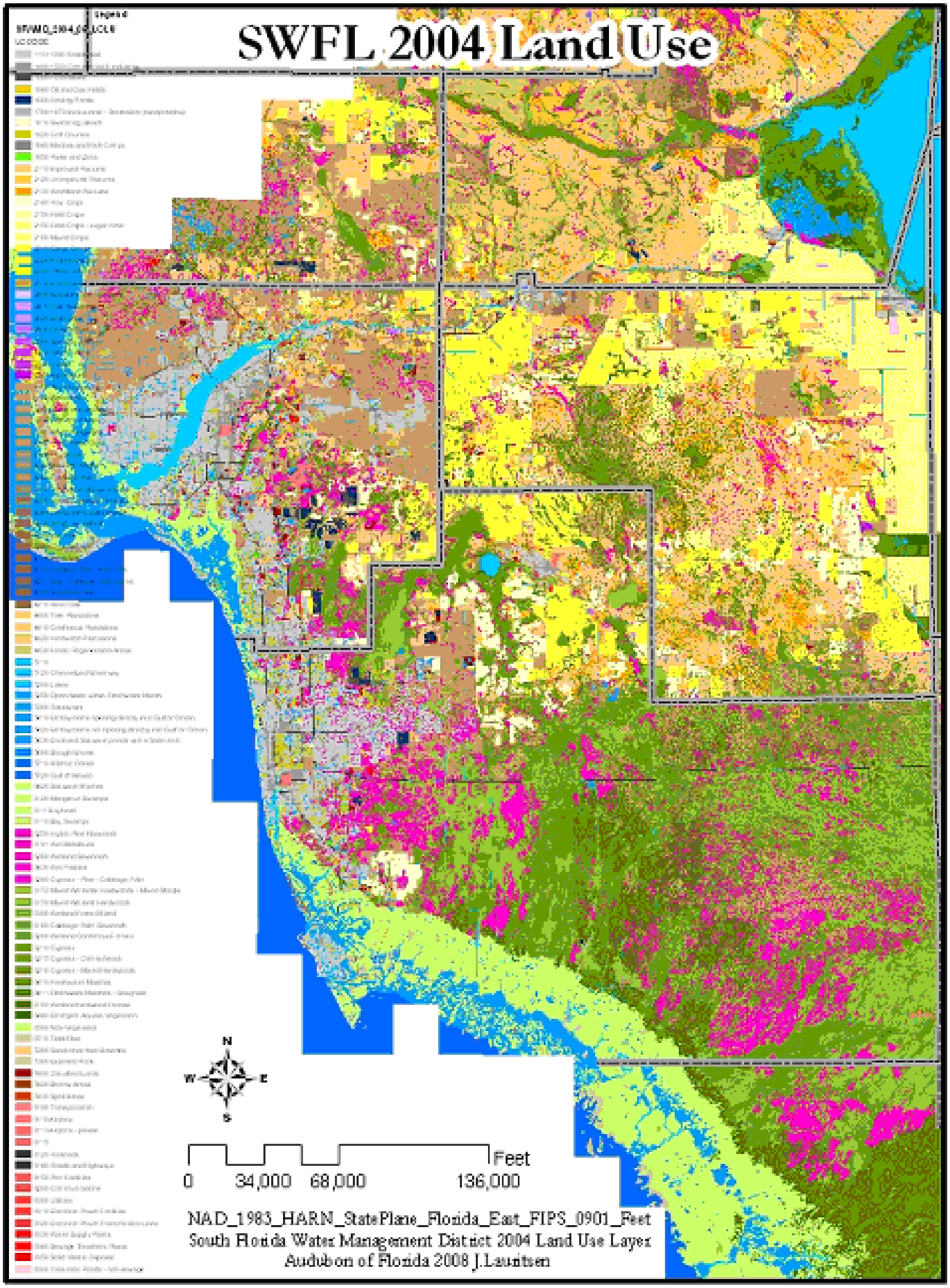


Figure 4. Two tone circles represent wood stork foraging locations recorded between October 13th 2006 and January 31st 2007 in a portion of Collier, Lee and Hendry Counties. This data set is part of an ongoing study documenting wood stork foraging in Southwest Florida. Most of the foraging recorded during this period is in association with Agricultural lands and along roadside ditches.

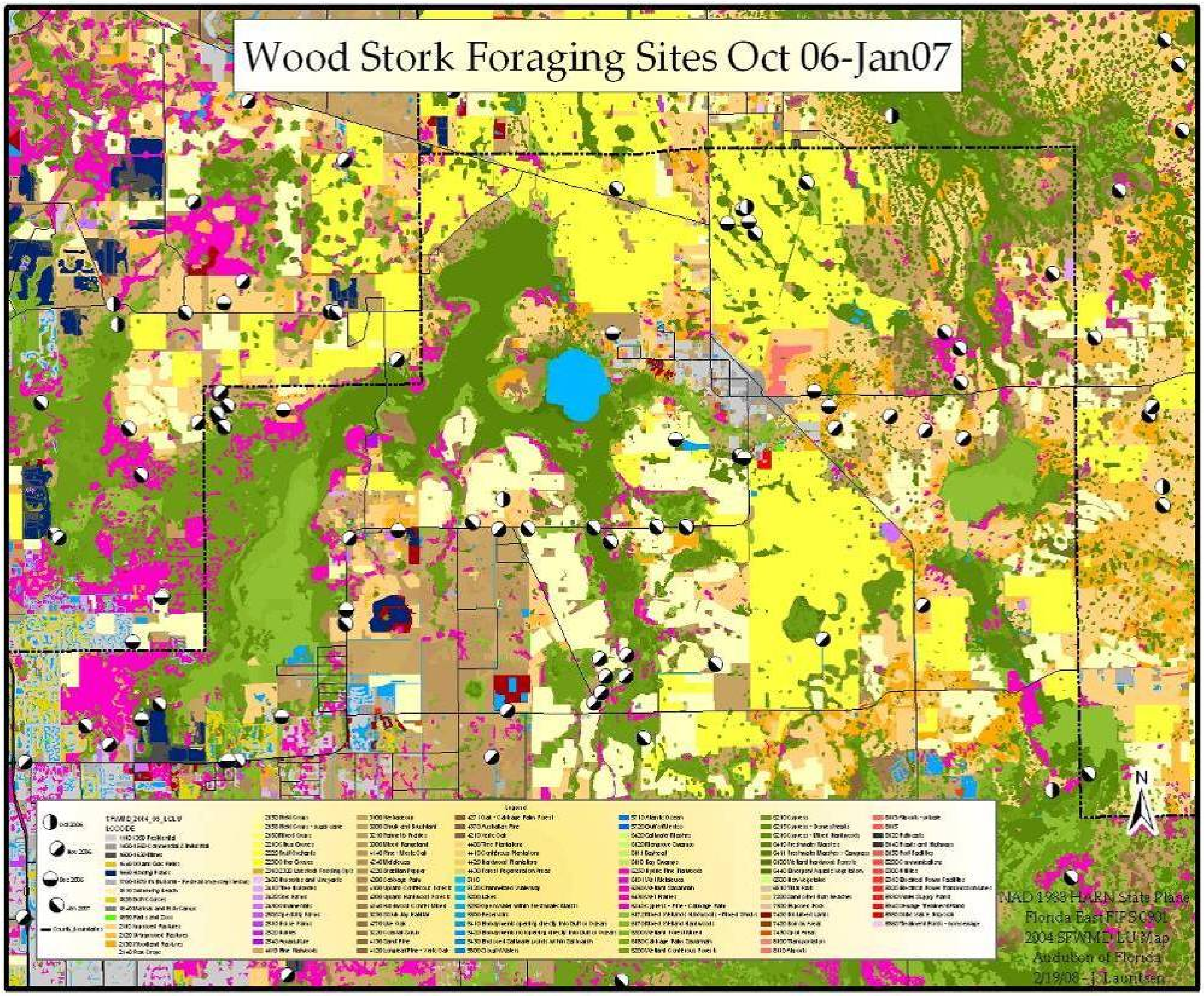
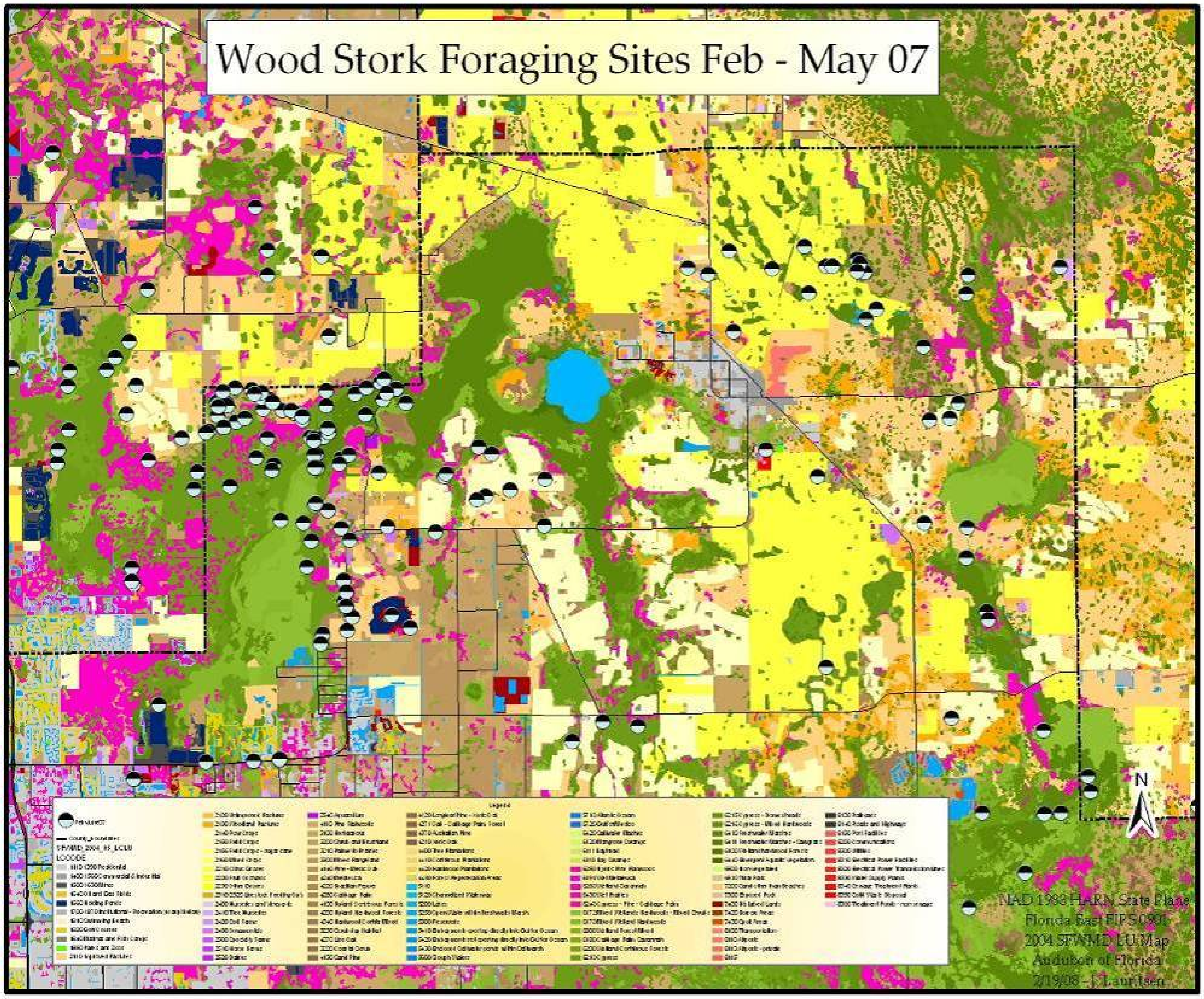


Figure 5. This map depicts the locations of wood stork foraging which was recorded from February through May of 2007. During this time wood storks were observed much more frequently foraging in deeper natural wetlands with hydroperiods in excess of 180 days. The Corkscrew Marsh watershed is the focus of the highest concentration of foraging recorded during this period.



A PRELIMINARY SUMMARY OF THREE STUDIES LINKING EVERGLADES LANDSCAPE PREY AVAILABILITY, WADING BIRD HABITAT SELECTION, PHYSIOLOGY, AND REPRODUCTION

Introduction

One of the key conceptual models underlying Everglades restoration is that hydrologic changes affect wading bird prey availability and ultimately nesting patterns. However, the mechanism by which prey availability affects wading birds and produces species-specific habitat use and nesting patterns has not been identified in the field. Documenting this relationship is important to verify one of the conceptual foundations of CERP, but also to allow for better predictions of how birds will respond to restoration. The series of studies summarized here is a comprehensive and coordinated effort to quantify the pathway linking landscape hydrology patterns, wading bird prey availability, habitat use, physiology, and reproduction. It builds on earlier published studies as well as ongoing experiments at FAU and SFWMD. This brief and preliminary summary is not meant to substitute for detailed descriptions and results of the individual studies. Readers looking for a thorough description of the research should consult Beerens (2008), Gawlik and Botson (2008), Herring (2008), and other references below. These studies and our recent progress on understanding of how hydrology affects wading birds was possible because of funding from the South Florida Water Management District (RECOVER), U.S. Fish and Wildlife Service, National Park Service, and the U.S. Army Corp of Engineers. We are also greatly indebted to our many perceptive colleagues who have generously shared their understanding of how this unique ecosystem functions.

Indicator species for the Everglades restoration, such as the White Ibis and Great Egret, differ in their sensitivity to hydrologic conditions (Gawlik 2002) and they exhibit different population trends (Crozier and Gawlik 2003). There is growing evidence that the population responses can be linked to how constrained a species is in its choice of habitats (Gawlik 2002, Beerens 2008). Searchers like the White Ibis are more constrained in their selection of foraging sites and tend to select high-quality patches and abandon them quickly, whereas exploiters like the Great Egret are opportunistic and tend to minimize searching effort by staying at foraging areas longer until prey densities are low (Gawlik 2002).

Serendipitously, the study years of 2006 and 2007 provided contrasting hydrological conditions and levels of prey availability thereby providing us with a natural framework for testing how the two species adjust their habitat selection, nesting patterns, and physiological condition in response to varying food availability. Hydrologic patterns differed drastically during the two years of the study, 2006 and 2007, producing a large difference in habitat quality. Experimental studies with White Ibis nestlings suggested that food limited growth and survival for this species in 2007 but not in 2006. Cumulatively, this evidence led to our characterization of 2006 as a year with good habitat conditions and 2007 as a year with poor habitat conditions.

We used a four-tiered approach to understand the relationship between Everglades prey populations and wading bird responses. First, as part of a CERP Monitoring and Assessment Plan (MAP) study we sampled Everglades' fauna across the entire ecosystem taking into consideration spatial and temporal factors that influence both prey species and foraging wading birds. Second, using radio-tagged model species (Great Egret as an exploiter and White Ibis as a searcher) we developed resource selection models to identify the important landscape variables that influence foraging habitat selection. Third, we measured physiological condition of adults in response to landscape level prey availability and differences in foraging strategies between the two species. Finally, we focused on reproduction and tested for differences in nesting success, fledging rate, chick physiologic condition, and chick growth in response to landscape prey availability and foraging strategy. The results presented here are preliminary in that we have not yet completed a thorough interpretation of the patterns at the higher integrated level.

Section 1. Everglades Fauna Concentrations During the Wading Bird Breeding Season

Methods

To quantify the availability of prey for wading birds across the Everglades landscape as part of the CERP Monitoring and Assessment Plan, we sampled fish and macroinvertebrates with a 1-m^2 throw trap during the dry seasons from December to May. We also sampled at sites where large flocks of wading birds (>30) were foraging to compare used versus available sites. See Gawlik and Botson (2007) for a detailed description terminology, sampling design and sampling methods.

Results & Discussion

Hydrologic conditions, prey concentrations and wading bird nesting effort differed considerably among 2005, 2006, and 2007. Water levels at the start of the 2005 dry season experienced a steady and rapid recession through the end of February, which likely triggered the initiation of nesting by wading birds. A series of rain events in early March reversed the seasonal water recession (Fig. 1), inhibiting the concentration of prey and producing widespread nest failure by most wading bird species (Cook and Call 2005). These reversals initiated a longer than usual period of rising water levels in which prey were produced and subsequently concentrated in the 2006 drydown. Hydrologic conditions in the 2006 dry season were close to optimal for wading bird nesting as suggested by Gawlik (2002). Water levels were well above average at the start of the dry season, unimpeded by major reversals, and receded steadily throughout the season. Furthermore, the late onset of the wet season in 2006 continued to provide ample foraging patches for fledging birds late in the season. This steady, prolonged recession in 2006 fostered the highest dry season prey densities (Fig. 2) and the most wading bird nests of the 3 years. The thorough recession and subsequent unusually dormant wet season of 2006 produced abnormally low water levels during the 2006 wet season and during the 2007 dry season, at least in the northern Everglades (Fig. 1). Like 2006, the 2007 dry season had few reversals and an uninterrupted recession; however, mean prey density and biomass at random sites declined significantly (Table 1, Fig. 2). The low water levels of the preceding wet season appeared to have constrained the growth and reproduction of prey populations leading into the 2007 dry season.

Prey density tended to be greater at foraging sites than at random sites during the two poor years 2005 and 2007, suggesting that while prey availability was low overall, birds were able to find some sites with higher prey densities. In 2006, however, there was no discernable difference in prey density between random and foraging sites, suggesting that high quality foraging patches were simply more common in the landscape.

During the first two years of this study it was apparent that one difference between the fish community in drying pools and the fish community in deeper water is that the former is dominated by large fish (> 2 cm) rather than small fish. This novel pattern is opposite of what is typically seen when sampling in deeper water (Loftus and Eklund 1994, Trexler et al. 2002). Interestingly, this pattern did not persist during 2007, as there was no discernable difference in proportion of prey sizes (Table 1, Fig. 2). The lack of difference between the density of small and large prey appears to be a function of the drought, whereby the density of large fish declined greatly and the density of small fish declined only slightly. The decline of large prey items in the landscape reduces the quality of prey patches, particularly for larger birds like the Wood Stork, which did not nest successfully in 2007.

Figure 1. Mean rainfall and stage level throughout the Florida Everglades from June 2004 to July 2005, June 2005 to July 2006 and June 2006 to July 2007. Shaded areas represent approximate wading bird nesting season. Stage values represent the mean of 17 gages Rainfall represents the mean of 13 gages.

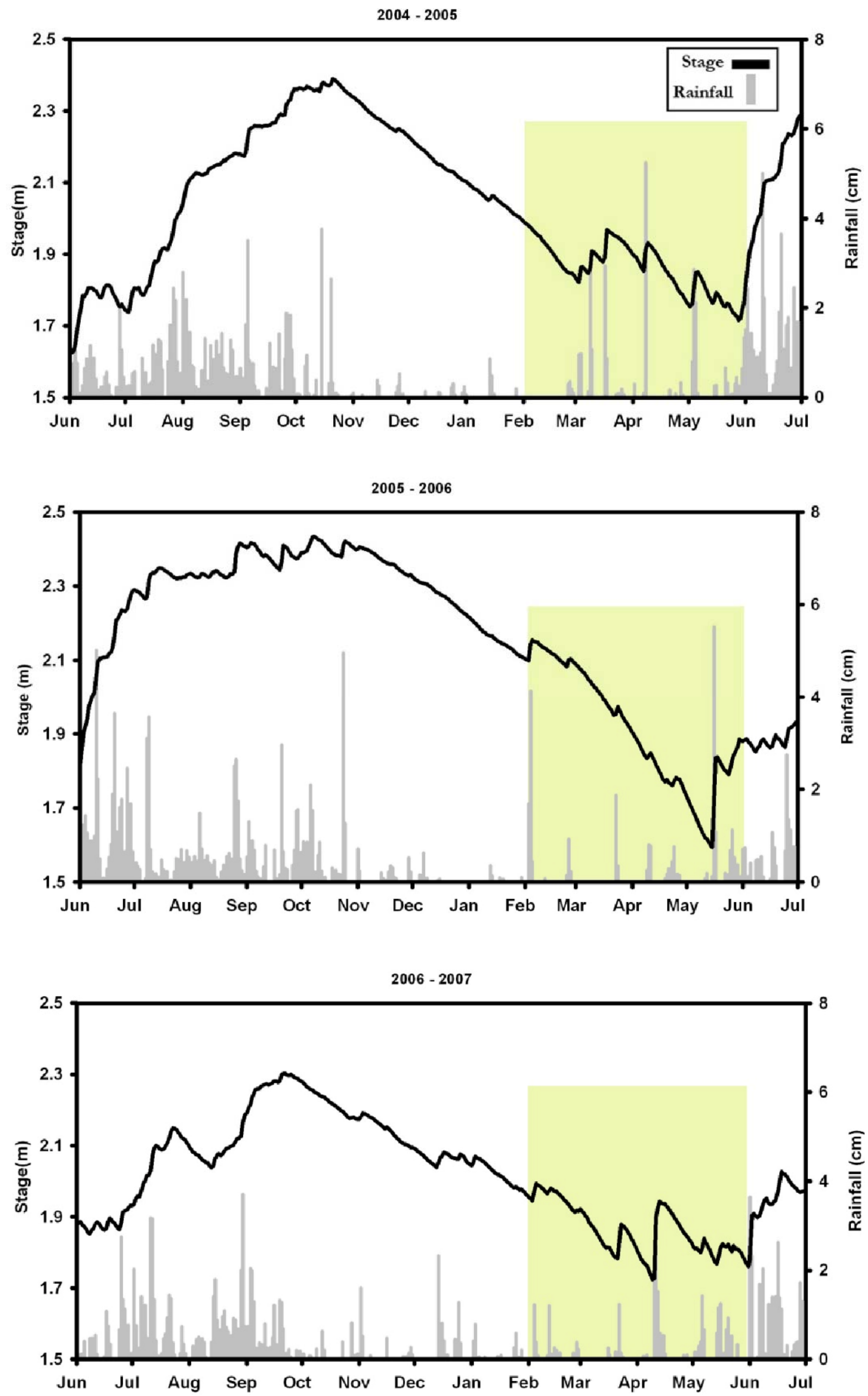
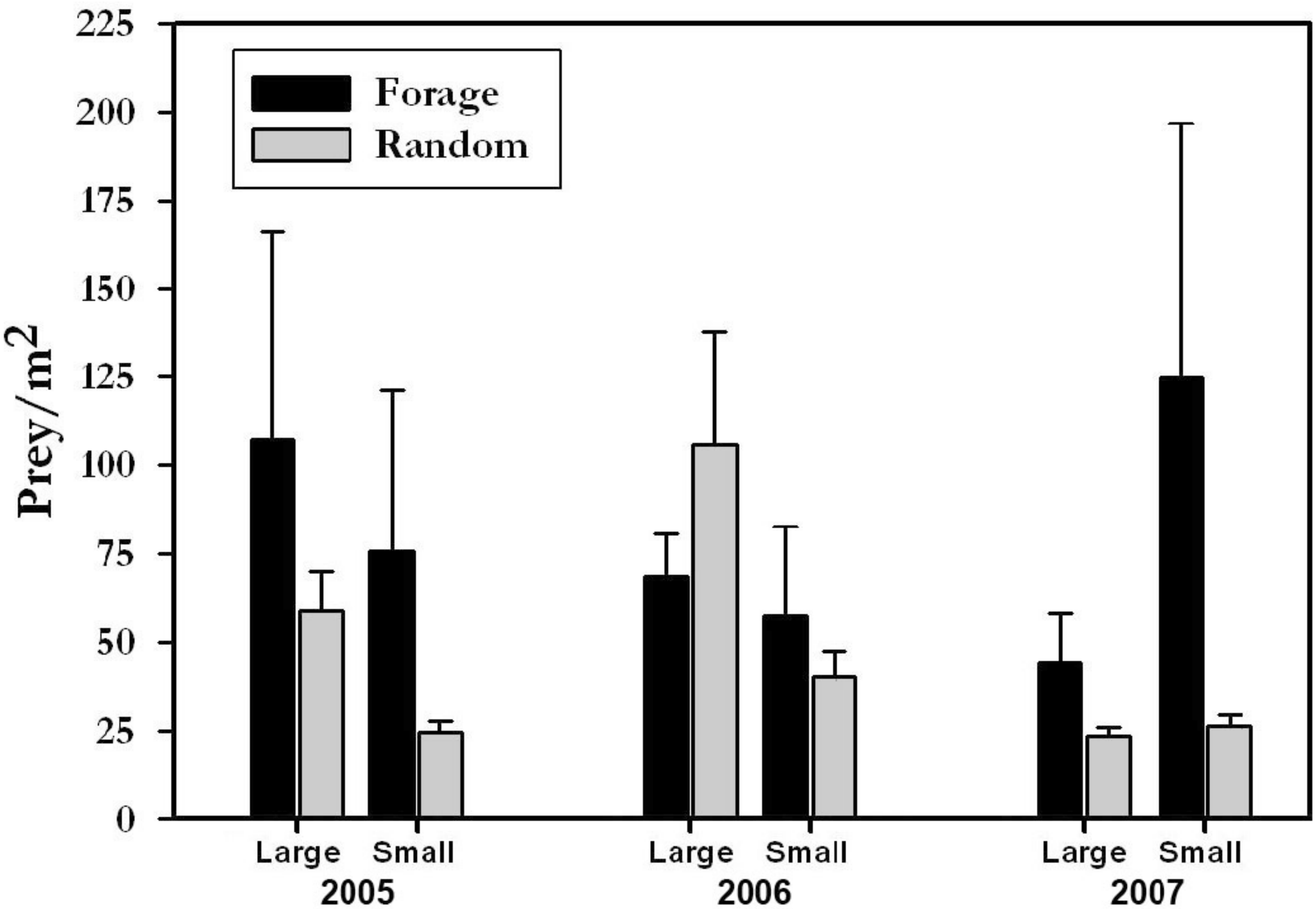


Table 1. Mean prey density, mean biomass (g), and the mean number of large prey found within 1-m² throw traps for random and foraging sites throughout the Florida Everglades in the dry seasons of 2005, 2006 and 2007. Data shown as the mean ± 1 SE.

Sample Type	Mean Prey Density (range)			Mean Prey Biomass			Mean Large Prey Density (≥2 cm)		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Random	81 ± 14 (0 -798)	142 ± 36 (1 - 3198)	51 ± 5 (0 - 633)	32 ± 5	48 ± 12	8 ± 1	58 ± 12	106 ± 32	23 ± 2
Forage	184 ± 98 (1 - 4124)	126 ± 34 (4 - 832)	170 ± 84 (1 - 3590)	25 ± 12	31 ± 12	12 ± 3	107 ± 58	68 ± 12	44 ± 14

Figure 2. Mean density of all prey items in 1-m² throw traps at random sites and wading bird foraging sites throughout the Florida everglades during the 2005, 2006 and 2007 dry season. Error bars are ± 1 SE.



The hydrological disparities among 2005, 2006, and 2007 were associated with differences in prey concentrations and wading bird nesting in a way that supports the key trophic hypothesis of restored water, higher prey availability, and higher wading bird nesting effort. This study provides evidence that both prey production and concentration act to limit wading bird nesting in different years. Although the preliminary pattern is encouraging, it should be viewed as tentative until data have been collected through a number of years with differing hydrologic conditions.

Section 2. Habitat Selection of Two Wading Bird Species with Divergent Foraging Strategies

Methods

We captured and radio-tagged Great Egrets (n = 77) and White Ibises (n = 127) prior to the initiation of breeding in 2006 and 2007 using a net gun and a modified flip trap (Herring et al. 2008). Radio-tagged birds were captured in the central and northern Everglades and thereafter, a subset were relocated three to four times a week from a plane. The habitat at foraging locations (n = 1,217) were compared with habitat parameters at random locations (n = 206,726) generated daily with ArcMap. Foraging and random locations representing available foraging sites were classified in ArcMap using five hydrological variables calculated from daily Everglades Depth Estimation Network (EDEN) water depths, five vegetation classes, vegetation diversity, and soil phosphorus. These variables represent processes that occur over a wide range of temporal scales to capture daily to decadal influences on habitat selection. These variables were used to develop resource selection functions (RSFs), which identified habitats that were selected by Great Egrets and White Ibises while accounting for changing habitat availability. The cumulative hazard function for each species and year combination were plotted to illustrate the seasonal change in probability of use of the landscape. An increasing function is evidence that overall probability of use of the landscape is increasing.

Results

Great Egrets, 2006 (Good habitat conditions)

Great Egrets selected shallow water depths (Fig. 3), low soil phosphorus levels, presence of cattail-dominated vegetation, and increased days since drydown, in order of descending importance based on the likelihood scores.

White Ibises 2006 (Good habitat conditions)

White Ibises selected shallow water depths (Fig. 3), low soil phosphorus levels, slow recession rates and short hydroperiods, respectively. White Ibises preferred sites where water was receding slightly slower (.254 cm/day ± .024 SE) than system-wide recession rates (.317 cm/day ± .002 SE; Fig. 4).

Great Egrets 2007 (Poor habitat conditions)

Great Egrets selected, in order of descending importance, rapid recession rates, shallow water depths (Fig. 3), cattail-dominated vegetation, sites that were still wet when a reversal occurred, low soil phosphorus levels, open water/high-impact urban dominated vegetation, and freshwater marsh and wet prairie dominated vegetation. In the poor habitat conditions year, Great Egrets were more selective of optimal water depths, in contrast to 2007, when they selected a broader range of less optimal water depths (Fig. 3). Selectivity for rapid recession rates dramatically increased in the poor habitat condition year ($P < .0001$; Fig. 4), receiving the highest likelihood score.

White Ibises 2007(Poor habitat conditions)

White Ibises selected, in order of descending importance, rapid recession rates, low soil phosphorus concentrations, shallow water depths, short hydroperiods, open water/high impact urban dominated vegetation, and sites that were still wet when a reversal occurred. Like the Great Egret, White Ibises were less selective of optimal water depths in the good habitat year than in 2007 (Fig. 3). Analysis of water depth at foraging locations indicated selection of foraging sites similar to depths selected by Great Egrets in the same year (Fig. 5).

Cumulative Hazard Functions

The cumulative hazard function indicated that the probability of birds using the landscape increased by Julian date in both years, suggesting that landscape features selected by Great Egrets and White Ibises were increasingly more suitable as the season progressed (Fig. 6). This pattern continued until the first major reversal (Fig. 6), which caused a decrease in the probability of use. Great Egrets in 2006 were an exception because probability of use simply stopped increasing after the reversal.

Figure 3. Relative probability of use for water depth. Depth selectivity is highest for White Ibises (WHIB) in 2006, followed by Great Egrets (GREG) in 2006, White Ibises in 2007 and Great Egrets in 2007.

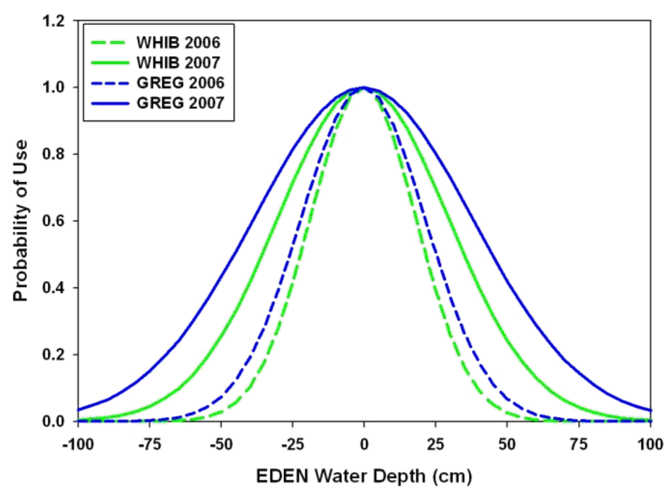


Figure 4. Yearly mean (± SE) recession rates at available and used sites by the Great Egret (GREG) and White Ibis (WHIB).

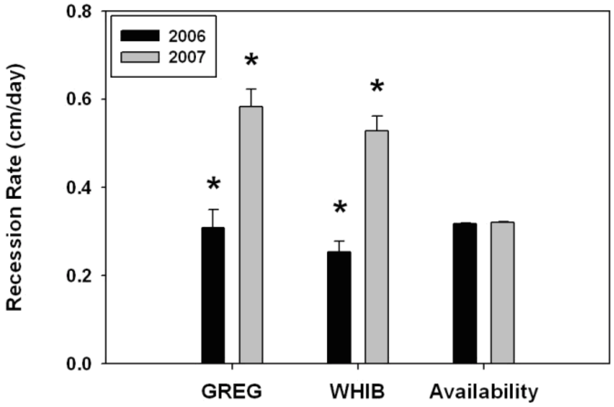


Figure 5. Yearly mean (± SE) EDEN depths, by Great Egret (GREG) and White Ibis (WHIB) use and availability.

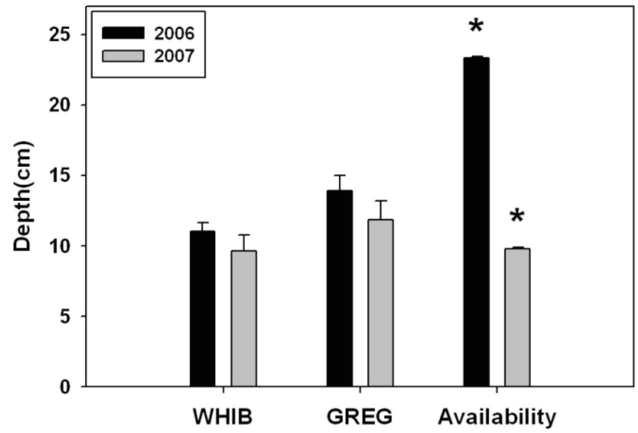
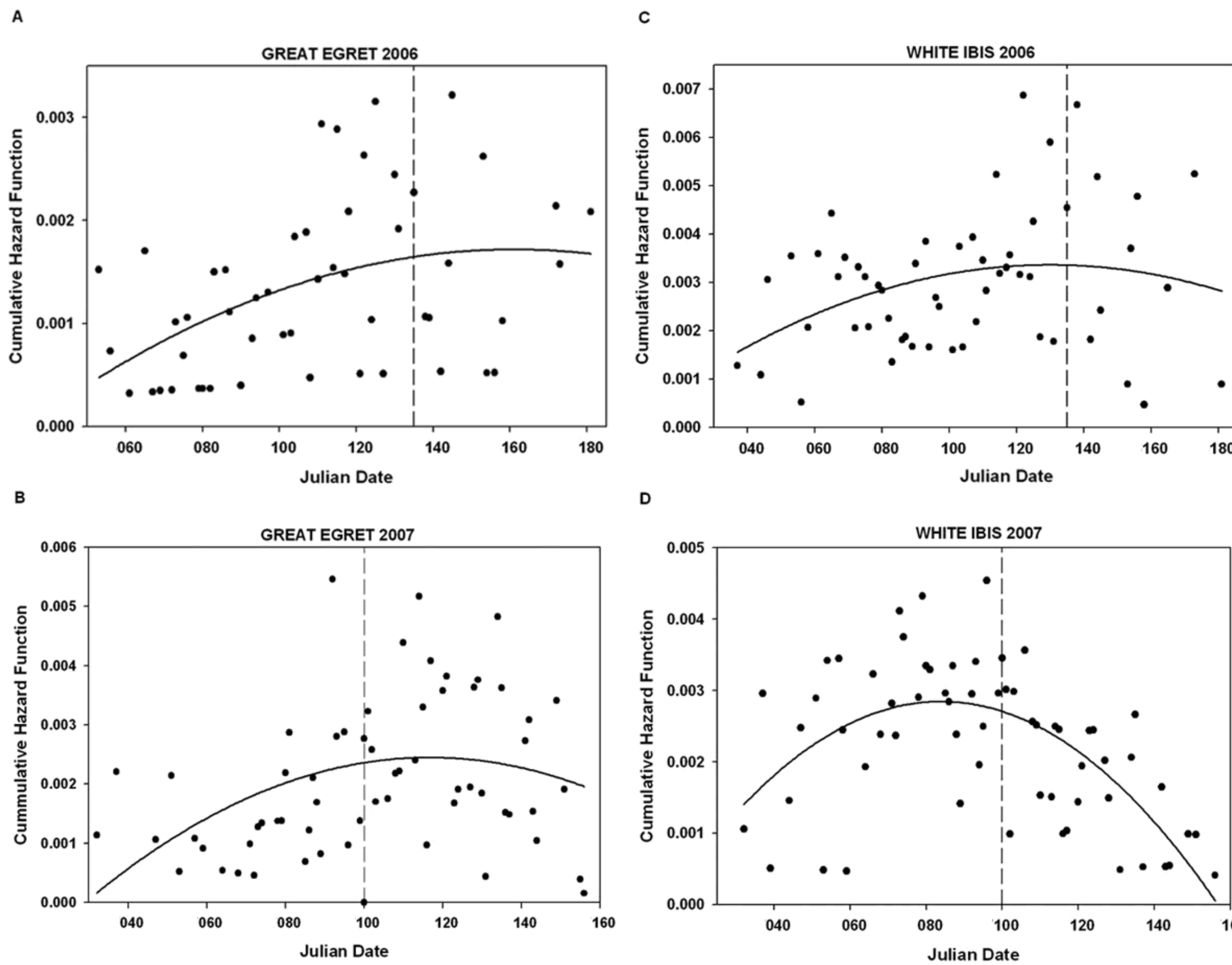


Figure 6. Cumulative hazard function (-log survivor function) depicting daily changes in the probability of use of the landscape for Great Egrets in 2006 (A) and 2007 (B) and White Ibises in 2006 (C) and 2007 (D). The dashed lines show the timing of a major reversal. An increasing cumulative hazard function is evidence for an increasing probability of use of the landscape.



Discussion

As expected, adult Great Egrets and White Ibises did not randomly select foraging locations, but rather displayed a clear preference for distinct habitat features. There appeared to be a relationship among resource availability, the temporal scale of the independent variable, and whether the response was similar or different between species. One set of independent variables differed strongly between years as a function of resource availability. Within this set, variables that change over short time scales, such as surface water dynamics (e.g. water depth, recession rates and site reversal) tended to produce a similar response by both species. In contrast, longer term processes involved in prey productivity such as days since drydown and hydroperiod produced a different response between species. Great Egrets consistently selected longer days since drydown, whereas White Ibises selected short hydroperiods.

A second set of independent variables that change so slowly they were invariant over the two years of our study produced a consistent selection pattern between years, although it sometimes differed between species. For example, both species avoided areas of high soil phosphorus concentrations and White Ibises consistently selected areas with short hydroperiods. The cumulative hazard functions suggest that in a good year, a reversal is less detrimental to Great Egret foraging than White Ibis foraging, and supports the notion that the latter species is more constrained in its use of habitat (Gawlik 2002). Modeling studies will be needed to confirm whether these differences in responses to food limitations are enough to explain the divergent population trends.

One of the strengths of the probability-based parameter estimates in this study is that the estimates can be imported directly into wading bird habitat suitability indices used for evaluating restoration scenarios. The estimates also provide an empirical predictive habitat model in nearly real time, that uses EDEN water depths and that can be linked to a GIS. The resulting maps identify areas likely to be used by wading birds and they highlight the changing probability of use of the landscape as water levels change and the season progresses. Identifying the key habitat characteristics of those high-quality patches for species with contrasting foraging strategies will provide a range of habitat conditions that can be used to guide restoration progress.

Section 3. A Mechanistic Link Between Prey availability and wading bird populations in the Everglades

Methods

We used the pre-breeding adult Great Egrets and White Ibises from SECTION 2. Those individuals were sampled for physiological markers and radio tracked throughout the remainder of the breeding season. Radio tagged adults were located in nesting colonies, we recorded clutch size and then monitored nest success and fledging rates, and sampled chicks to determine their physiological condition and growth rates for both radio tagged and random nests. In this study we focused on corticosterone and stress protein physiological markers, which generally increase during periods of increased stress, which can lead to reproductive failure.

Results and Discussion

Pre-breeding adult physiology measures suggested that in a year with high prey densities both Great Egrets and White Ibises were in good physiological condition (low levels of stress proteins and fecal corticosterone). During a year with poor habitat conditions, (2007), ibis physiological condition declined compared to 2006; stress protein 60 and fecal corticosterone metabolites were higher during the 2007 pre-breeding period in ibis (Figs 7-8). However, Great Egret stress levels remained stable between the two years.

Figure 7. Adult White Ibis fecal corticosterone levels during the 2006-2007 pre-breeding period in the Arthur R. Marshall Loxahatchee National Wildlife Refuge, Water Conservation Area 2A, and 3A of the Florida Everglades.

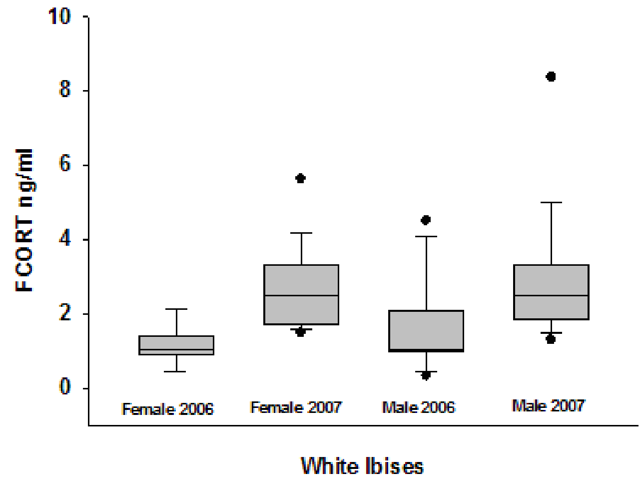
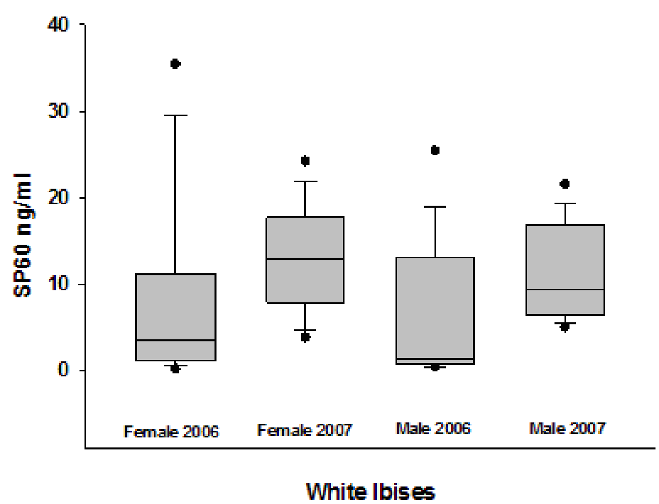


Figure 8. Adult White Ibis stress protein 60 levels during the 2006-2007 pre-breeding period in the Arthur R. Marshall Loxahatchee National Wildlife Refuge, Water Conservation Area 2A, and 3A of the Florida Everglades.



Nesting results suggest that White Ibises modify their clutch size during years with poor habitat conditions (18% lower during 2007) in accordance with the life history traits of a long-lived species, whereas Great Egrets maintained similar clutch sizes during years with poor and good habitat conditions. The strategy of the great egret is advantageous in years with poor habitat if birds are more likely to experience brood reduction rather than total nest failure, or if habitat conditions improve rapidly during the nesting period, allowing for the third egg to hatch and or chick to fledge (Bet Hedging; Lack 1947). This bet hedging approach appears to allow Great Egrets to produce successful nests in poor years and may maximize their reproductive efforts during average to above average years. The strategy of white ibises favors a searcher foraging strategy for wading birds with short legs. These species have less ability to withstand change in hydrological conditions (e.g., depth) and require more numerous high quality foraging patches. Poor pre-breeding prey availability may be a cue for this species to lower its clutch size in preparation for increased costs of locating suitable high quality foraging patches to provision chicks.

Corresponding chick physiology results found White Ibis chicks to be in poorer physiological condition in 2007 than in 2006 based on measures of long-term stress (SP60) and growth rates (mass). Great Egret chicks, however, had increased levels of fecal corticosterone but no response in the growth rates (mass) of first- and second-hatched chicks during the poor year with lower prey biomass. Perhaps the increase in corticosterone in Great Egret chicks is not above a threshold that results in deleterious effects. Alternatively, the increase in Great Egret chick corticosterone levels may facilitate increased begging and provisioning (Kitaysky et al. 2001)

Taken as a whole, this study demonstrated the significant effects of landscape level prey availability and the habitat variables that influence prey availability on pre-breeding physiological condition of great egrets and white ibises and their reproductive responses. The responses of the two species is consistent with the notion that food availability has played an important role in the long-term nesting trends of both species, with ibis responding more acutely to lower prey availability. Results from adult, chicks, and nest survival supported the Prey Availability Hypothesis (Gawlik 2002), that both density and factors that make prey vulnerable to predation (e.g., recession rates, hydrological reversals) are important during all stages of the reproduction.

Everglades Management Recommendations

Collectively, our results and previous studies provide strong support for the trophic hypothesis that is a foundation of CERP. Continued improvement in our understanding of the interaction between hydrology and wading bird prey availability will allow us to move beyond the question of whether food limits nesting patterns in the Everglades to ask instead under which conditions does one component or another of food availability limit wading bird nesting patterns.

These studies have illuminate an important pathway for how hydrological conditions can influence prey availability during the wading bird breeding season, differential habitat use and physiological responses of foraging searcher and exploiter species, and ultimately their nesting responses. The fact that White Ibises were more selective of foraging sites, particularly after hydrological reversals, lowered their clutch size, and fledged chicks in poorer physiological condition relative to Great Egrets in poor habitat condition years, suggest that they may not respond similarly to management of the Everglades. Short term water level reversals will likely produce earlier, and larger negative responses (e.g., foraging site abandonment, increased stress, and nest failure) in White Ibis than Great Egrets, given the decreases in probability of habitat use and daily nest survival associated with increasing coefficient of variation of recession rates (hydrological reversals). Modest increases in water depth, which do not preclude wading birds from foraging, may slow recession rates enough to disrupt the nesting cycle and cause nest failure These effects may be more acute during years with poor habitat conditions, when White Ibises are more dependent than other years on the hydrologic process of concentrating prey. Given Great Egrets responded less acutely to changing hydrological conditions during this study, restoring hydrological conditions across the Everglades should not be expected to produce as large or as quick of a response in nesting patterns for egrets as for ibis.

A key effect of drought on wading birds was also apparent from our studies. The main impact on birds does not appear to be a reduction in total prey density but rather a decrease in the larger aquatic animals (> 0.2 cm) that make up the bulk of wading bird diets, particularly for large birds like Wood Storks and Great Egrets. There is a smaller reduction in density for invertebrates like crayfish, which are the main prey of White Ibis. A refined understanding of the effects of droughts and floods on the concentrations of individual prey species and subsequently on the associated wading bird predators, will greatly improve our ability to predict the effects of short term water conditions after a specific sequences of years with varying hydrologic conditions.

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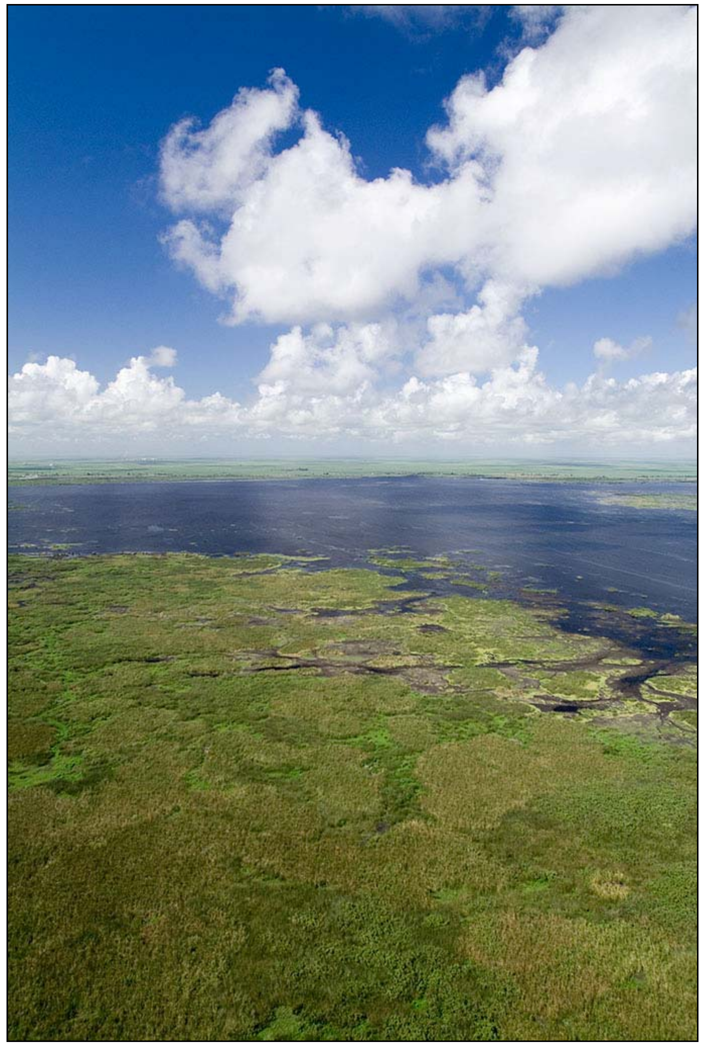

This document is the result of continued cooperation among a diverse group of ecologists. It is not a peer-reviewed scientific publication; narratives reflect the views of individual authors rather than the collective participants. Photos provided by Ralph Arwood, Erynn Call, Chuck Hanlon, Andrew Horton, Lori Oberhofer, John Simon, and Joel Curzon. The South Florida Wading Bird Report is available on the web at www.sfwmd.gov.

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