SOUTH FLORIDA WADING BIRD REPORT

Volume 25 | Mark I. Cook and Michael Baranski, Editors | September 2020

SYSTEMWIDE SUMMARY

NESTING IN SOUTH FLORIDA

An estimated 37,303 wading bird nests (excluding Cattle Egrets [CAEG], which do not rely on wetlands) were initiated in South Florida during the 2019 nesting season (November 2018 to July 2019). This is a relatively modest nesting effort compared to recent years. It is only 72% of the 10-year average annual number of nests (51,867.1 nests) and almost 3.7 times smaller than the banner nesting effort of 2018 (138,834 nests), which was the largest nesting effort observed since comprehensive systemwide nesting surveys began in 1996.

Most wading bird species exhibited moderately or slightly reduced nesting effort in 2019 relative to 10-year annual averages. White Ibis (WHIB) nesting effort (21,667 nests) was reduced by 27% (almost 8,000 nests) compared to the 10-year annual average, and it was almost 5 times lower than the 2018 count (100,784 nests). Given the WHIB is the most numerous nesting species in South Florida (typically between 45% and 78% of all wading bird nests), this decrease accounted for much of the reduction in the 2019 total nest count. Great Egrets (GREG) produced 3,487 nests during 2019, the lowest count since 2008 and a 64% decrease compared to the 10-year average. The federally threatened Wood Stork (WOST) has exhibited a marked increase in nesting effort during the past 2 years, but produced only 1,488 nests in 2019, which is fewer than half the 10-year average estimate (2,990.6 nests). Roseate Spoonbill (ROSP) nesting effort (472 nests) also declined slightly (8%) compared to the 10-year average.

The smaller *Egretta* heron species have exhibited consistent and steep declines in nest numbers over recent years, such that very few of these birds now nest in South Florida. In 2019, 1,453 Tricolored Herons (TRHE) and 3,500 Snowy Egret (SNEG) nests were counted, representing a 5% and 22% increase in nesting effort, respectively, relative to the 10-year annual averages. While this is a moderate improvement, the counts remain considerably lower than the 10,000 or so pairs of each species that historically nested in South Florida (Frederick et al. 2009). The exception to the improved nesting effort in 2019 was the Little Blue Heron (LBHE; 354 nests), which declined by 29% compared to the 10-year average. However, a relatively large number of small heron nests (2,875 nests) could not be identified to species this year (they were either LBHE, SNEG, or CAEG nests), such that the estimated counts for LBHE, SNEG, or both are relatively conservative.

Wading bird nesting is not evenly distributed in South Florida (**Figure 1**). The most important area in terms of numbers of nests from a regional perspective is the Everglades Protection Area (hereafter Everglades), which comprises the Water Conservation Areas (WCAs) and Everglades National Park (ENP) and supports between 70% and 90% of all nests annually. Wading birds initiated an estimated 31,908 nests in the Everglades during 2019, 85.5% of all nests in South Florida. This nesting effort is 77% of the decadal average (41,290.9 nests), 68% of the 5-year average (46,976.6 nests), and only 26% of last year's banner nesting effort when a record 122,571 nests were produced. The next most important nesting area is Lake Okeechobee, which typically supports about 10% of South Florida's nests. This year, the lake produced an estimated 1,837 nests, less than a quarter of the 10-year average (5,319.1 nests) and the lowest count since 2008 (see *Wading Bird Nesting at Lake Okeechobee* section). The lake accounted for 4.9% of the nests in South Florida. Another regionally important nesting area during 2019 was Florida Bay (1,381 nests). The Kissimmee Lakes area also is an important nesting region but was not surveyed in 2019.

In terms of the spatial distributions of individual species in South Florida, the Everglades supported most of the nesting WHIB, GREG, WOST, SNEG, and LBHE (97%, 79%, 62%, 82%, and 48**%** of their total nests, respectively), but only a small proportion of the TRHE nests (8% of their nests). Florida Bay and Lake Okeechobee supported most of the nesting TRHE (55% and 21% of their nests, respectively), but relatively few SNEG or LBHE nests (fewer than 14% of nests).

A nesting area that has experienced substantially reduced nesting activity in recent years is Audubon Florida's Corkscrew Swamp Sanctuary. This historically important nesting area, which supported up to 7,000 WOST nests per year in the 1960s and often more than 1,000 nests per year in the early 2000s, has failed to support nesting during 8 of the past 10 years. WOST did nest at Corkscrew Swamp Sanctuary in 2019, but the number of nests was relatively low (49 nests). The loss of critical WOST foraging habitat in southwestern Florida and reduced hydroperiods in the sanctuary itself may be responsible for this dramatic decline.

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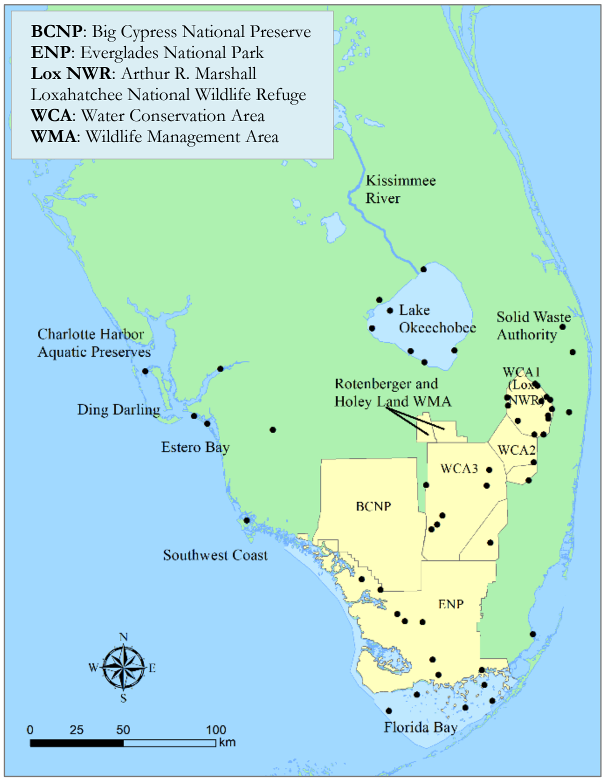

Figure 1. Locations of wading bird colonies with 50 or more nests in South Florida, 2019.

Nesting in the Everglades

A primary goal of the Comprehensive Everglades Restoration Plan (CERP) and other restoration programs in South Florida is the return of healthy populations of breeding wading birds to the Everglades. CERP predicts that restoration of historical hydropatterns will result in the return of large, sustainable breeding wading bird populations, reset the historical timing of nesting, and encourage birds to nest again at the large colonies in the coastal region of ENP (Frederick et al. 2009). There are two sets of performance measures aimed at assessing these responses, based on historical ecological conditions and the hydrology-prey-foraging relationships that govern wading bird reproduction in South Florida. CERP's performance measures (http://www.evergladesplan.org/pm/recover) include the 3-year running averages of the number of nesting pairs of key wading bird species, the timing of WOST nesting, and the proportion of the population that nests in the coastal ecotone (Ogden et al. 1997). In addition, the annual Stoplight Reports have added two other measures: 1) the ratio of visual to tactile wading bird species breeding in the Everglades, and 2) the frequency of exceptionally large WHIB breeding events (Frederick et al. 2009).

Nest Numbers

Annual nesting effort is assessed using the average nest count from three successive nesting seasons to account for any large natural fluctuations in annual nesting effort. The primary indicator species are GREG, WHIB, WOST, and SNEG (Ogden et al. 1997) for mainland Everglades and ROSP for Florida Bay. TRHE originally was included among the mainland species but has proven difficult to monitor during aerial surveys due to its cryptic plumage and tendency to nest below the tree canopy. GREG, WHIB, and WOST exhibited reduced nesting effort in the Everglades during 2019 relative to 2018 (**Figure 2**), but all three species met their CERP numeric restoration targets based on the 3-year running averages (**Table 1**). In terms of long-term trends, GREG and WHIB have exceeded target counts every year since 1996 and 2000, respectively, while WOST have exceeded their target nine times since 2000. SNEG nesting effort increased in 2019 relative to the last decade but has not exceeded its target since 1986 (**Table 1**).

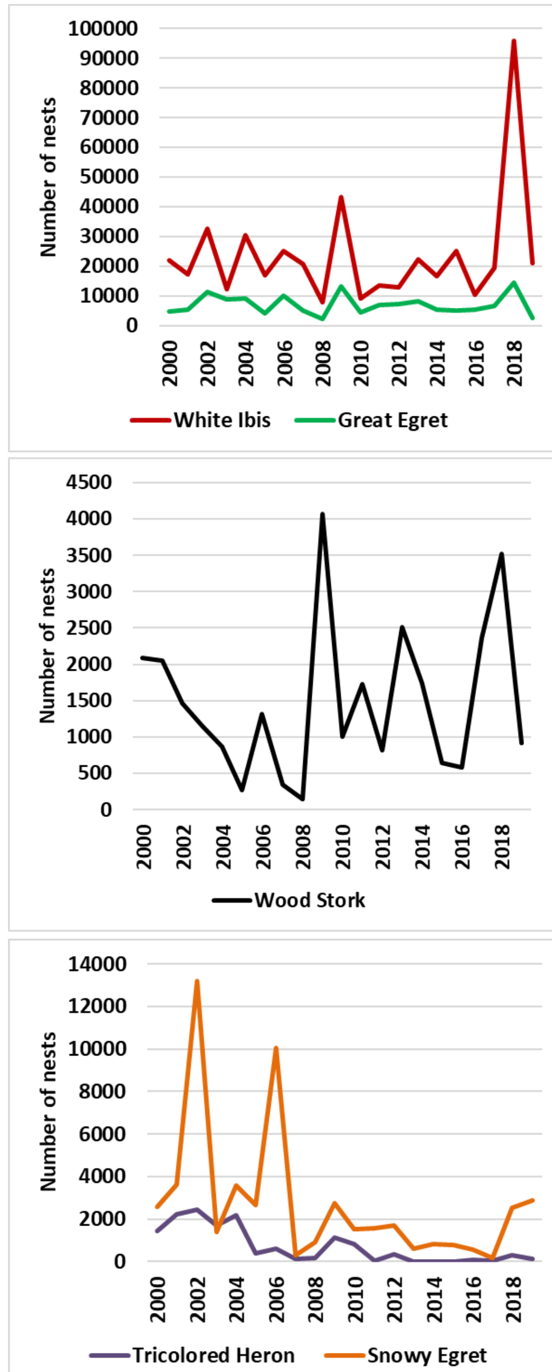

Figure 2. Wading bird nest numbers in the Everglades Protection Area (Water Conservation Areas and Everglades National Park) for individual species since 2000.

Table 1. Three-year running averages of the number of nesting pairs for the four indicator species in the Everglades (Provided by: Peter Frederick). Bolded years are those that meet minimum criteria.

Period	GREG	SNEG	WHIB	WOST
1986-1988	1,946	1,089	2,974	175
1987-1989	1,980	810	2,676	255
1988-1990	1,640	679	3,433	276
1989-1991	1,163	521	3,066	276
1990-1992	2,112	1,124	8,020	294
1991-1993	2,924	1,391	6,162	250
1992-1994	3,667	1,233	6,511	277
1993-1995	3,843	658	2,107	130
1994-1996	**4,043**	570	2,172	343
1995-1997	**4,302**	544	2,850	283
1996-1998	**4,017**	435	2,270	228
1997-1999	**5,084**	616	5,100	279
1998-2000	**5,544**	1,354	**11,270**	863
1999-2001	**5,996**	2,483	**1,655**	**1,538**
2000-2002	**7,276**	6,455	**23,983**	**1,868**
2001-2003	**8,460**	6,131	**20,758**	**1,596**
2002-2004	**9,656**	6,118	**24,947**	1,191
2003-2005	**7,829**	2,618	**20,993**	742
2004-2006	**8,296**	5,423	**24,926**	800
2005-2007	**6,600**	4,344	**21,133**	633
2006-2008	**5,869**	3,767	**17,541**	552
2007-2009	**6,956**	1,330	**23,953**	1,468
2008-2010	**6,715**	1,723	**21,415**	**1,736**
2009-2011	**8,270**	1,947	**22,020**	**2,263**
2010-2012	**6,296**	1,599	**11,889**	1,182
2011-2013	**7,490**	1,299	**16,282**	**1,686**
2012-2014	**7,041**	1,017	**17,194**	**1,696**
2013-2015	**6,300**	710	**21,272**	**1,639**
2014-2016	**5,328**	837	**17,379**	995
2015-2017	**5,655**	639	**17,974**	1,195
2016-2018	**8,803**	1,224	**41,465**	**2,152**
2017-2019	**7,965**	2,856	**44,967**	**2,282**
Target Minima	4,000	10 – 20k	10 – 25k	1.5 - 2.5k

The regional declines of *Egretta* herons over the last decade have been particularly acute in the Everglades (**Figure 2**). This year's nesting effort was an improvement compared to recent years but remained considerably lower than historical numbers (about 10,000 nests per year for each species). The number of SNEG nests in 2019 (2,866 nests) was 2.1 times the annual average of the last 10 years (1,349.2 nests), but less than three-quarters of the average from 1999 to 2008 (3,948.8 nests). TRHE produced 121 nests, which is less than half the decadal average (285.5 nests) and almost 11 times lower than the average from 1999 to 2008 (1,297.7 nests). The cause of the sharp declines in *Egretta* nesting has yet to be determined.

In Florida Bay, ROSP produced 282 nests, which is comparable to the 10-year average (278.9 nests) but only 22% of the target 1,258 nests per year. From a historical perspective, this is only 63% of the 34-year mean (445.8 nests) and far below the mid-20th century nesting effort when more than 1,000 nests per year were common (J. Lorenz, personal communication). In the WCAs and mainland ENP, numbers of ROSP nests (228 nests) were similar to the 10-year average (217.2 nests).

Spatial Distribution of Nests

The estuarine region of ENP historically supported approximately 90% of all nesting wading birds in the Everglades, probably because it was the most productive region of the Everglades ecosystem. During the past 50 years, productivity has declined due to reduced freshwater flows, and the location of nesting has shifted to inland colonies in the WCAs or elsewhere in the southeastern United States. An important goal of CERP is to restore the hydrologic conditions that will re-establish prey availability across the southern Everglades landscape, which in turn will support the return of large successful wading bird colonies to the traditional estuarine rookeries. In 2019, ENP supported 42.3% of nests, while WCA-3A and WCA-1 supported 39.6% and 18.1%, respectively. The proportion of nests in the estuarine region in 2019 was one of the highest recorded in recent decades and continues a trend of increased nesting in this area compared to the lows of the 1990s and early 2000s (2% to 10%).

The locations of ROSP nesting colonies within the Florida Bay area have shifted in recent years. Where most nesting historically occurred on small keys within the bay itself, many birds have moved during the past decade to mainland colonies adjacent to the coast (e.g., Madeira Hammock and Paurotis Pond colonies supported 150 nests during 2016, 41% of all nests in the region). However, this year, fewer birds nested at these two colonies (30% of 282 nests) and a greater proportion nested on small keys within the bay. Other individuals have deserted Florida Bay entirely. Since 2011, an average of approximately 200 ROSP pairs have nested at colonies in the central freshwater Everglades such as northern WCA-3A and along the gulf coast of ENP. This nesting effort remained steady in 2019, with 228 nests found in Everglades colonies.

Timing of Nesting

WOST nesting success is highly dependent on the availability of aquatic prey (fish), which are easy to find and feed upon when concentrated at high densities in shallow water during the dry season (winter-spring), but are not available in the wet season (summer-fall) when they move into deeper waters and disperse across the landscape. To successfully fledge their young, WOST require a continuous supply of abundant and concentrated fish throughout the reproductive period. WOST have a relatively long reproductive period (approximately 4 months), so it is critical they start nesting early in the dry season to ensure nestlings have time to fledge and gain independence prior to the onset of the rainy season when fish availability declines. WOST nesting historically started in November or December; however, since the 1970s, nesting initiation gradually has shifted to January to March (Ogden 1994). This delay is associated with reduced nesting success (Frederick et al. 2009) and is thought to occur because of a reduction in the amount and quality of the high-elevation (short-hydroperiod) wetlands that provide foraging habitat early in the nesting season. In 2019, WOST nesting started relatively early, with a possible first lay date in mid-January. While this is a little later than the December/early January start dates from the past 2 years, it is considerably earlier than in 2016 (late March) and 2015 (early February).

ROSP in Florida Bay also have exhibited a recent shift towards later nesting. For at least 70 years (1936 to 2009), ROSP nest initiations in the northeast region of the bay consistently fell between October 1 and December 31. However, as of 2010, nesting began to start increasingly later in the season; from 2010 to 2014, nesting started between January 1 and 10; in 2015, it began on January 24; and in 2016, it began on February 5, the latest start date ever recorded. Moreover, the timing of laying appeared to be getting considerably more asynchronous both within and among colonies. While nest initiations within the bay historically would span a few weeks, lay dates during the past 2 years have extended from January through April. These changes in the phenology and synchrony of nesting might suggest that the timing of optimal foraging conditions for ROSP is changing both temporally and spatially within Florida Bay. However, 2017 and 2018 were notable for a complete reversal of this trend, with most nest initiations starting in November/December. In 2019, nest initiations in the northeast region of the bay were relatively late again, with the first eggs laid in early January and laying continuing through March. The reasons for these patterns are unclear, but they likely relate to changes in where and when optimal foraging conditions become available, possibly as a result of sea level rise (see *Roseate Spoonbill Nesting in Florida Bay* section).

Nesting Success

Nest success of CERP indicator species in the Everglades often is low and highly variable in time and space, with average probabilities of fledging at least one offspring ranging between 35% and 49% for the four species (derived from 2010 to 2015 data). During 2019, nest success was monitored for just two species, WHIB and GREG, and was low for both species. WHIB nesting success (probability of fledging at least one nestling; n = 150 nests) was only 19%, with most nests failing at the incubation stage. Of 43 marked GREG nests, 38 nests failed at the incubation stage and did not hatch any nestlings; subsequent fledging success of surviving nests was not determined but likely was very low. In contrast to these observations was the likely high nesting success of *Egretta* species. Nesting success was not quantified for SNEG, TRHE, and LBHE; however, relatively large numbers of these species' fledglings were noted in colonies towards the later end of the nesting season (see *Water Conservation Areas 2 and 3, and A.R.M. Loxahatchee National Wildlife Refuge* section).

Role of Hydrology and Food Availability on Nesting Patterns

The most important process affecting wading bird nesting in the Everglades is the availability of prey (fishes and aquatic invertebrates). Prey availability is a function of prey production (the amount and size of prey animals) and vulnerability to capture by birds, with both components strongly affected by hydrologic conditions (Frederick and Ogden 2001, Herring et al. 2011). In a hydrologically fluctuating wetland such as the Everglades, prey production is influenced largely by the duration and frequency of wetland flooding and drying, with optimal conditions for population growth varying by species. Most fish populations peak after extended periods (multiple years) of relatively deep, flooded conditions over extensive areas of wetland (Trexler et al. 2005), while some invertebrate populations grow best during moderate hydroperiods punctuated by periodic dry conditions (Dorn and Cook 2015).

A particularly important prey group in the Everglades are the crayfish, which are critical for fueling WHIB nesting colonies (Boyle et al. 2014). Crayfish populations are strongly limited by predatory sunfishes such as warmouth that eat the small (young-of-the-year) juveniles. Once crayfish grow beyond a certain size, they are less sensitive to this fish predation. During periodic dry conditions, predatory fish populations decline, but crayfish can survive in their burrows until the rains return and water levels rise again during the wet season. At this point, adult crayfish emerge and release their young into a marsh habitat that is largely free of fish predators, allowing for a temporary (1 to 2 years) boost in crayfish populations (Dorn and Cook 2015).

Prey vulnerability to capture is determined largely by water depth and whether the water level is rising or falling. Prey become easiest to capture during drying conditions when water levels decline to depths at which birds can forage effectively (5 to 30 cm) and the areal coverage of water shrinks such that prey become concentrated at relatively high densities (Gawlik 2002, Cook et al. 2014). Conversely, prey vulnerability declines when water level rises and concentrated prey can disperse into the marsh. Prey availability, therefore, is naturally variable among years depending on antecedent and current water conditions. Accordingly, wading bird nesting effort and success fluctuate considerably from year to year.

The considerable decline in nesting during 2019 relative to the banner nesting season of 2018 demonstrates the critical role of hydrology and its corresponding effects on prey availability and nesting responses. The 2018 nesting season was highly successful because it experienced an unprecedented series of fortuitous hydrologic conditions that were near optimal for prey availability prior to and during the nesting season. Of note for 2018 were the conditions during the preceding wet season (June to October 2017), which included record-breaking rainfall driven primarily by Hurricane Irma and two tropical storms. This led to long periods of relatively wet conditions with water levels that remained aboveground for extended periods across large areas of the Everglades. This likely boosted prey (fish and crayfish) production over large areas of the ecosystem. Following the wet summer of 2017, the 2018 winter to spring breeding season (December 2017 to May 2018) was drier than average. This led to a relatively continuous decrease in water level across the Everglades landscape and provided ideal water levels and recession rates for concentrating prey and providing optimal foraging conditions for birds across large areas of the Everglades until late into the dry season.

The antecedent conditions leading into the 2019 nesting season were very different from those of 2018. While the wet season preceding 2019 initially was wetter than average, water levels peaked relatively early (June to July 2018), and by the start of the nesting season in December 2018, depths were below to considerably below average, depending on the region. This led to shorter hydroperiods and a smaller spatial extent of flooded habitat, which limited prey (fish and crayfish) production across the Everglades landscape, particularly in critical foraging habitats of the higher elevation marshes (marl prairies in ENP and Big Cypress Basin) that currently are over-drained. During the early 2019 dry season (December 2018 through January 2019), a relatively continuous drop in water level across the Everglades landscape provided moderate recession rates for concentrating prey and providing foraging habitat across certain areas of the Everglades. However, a large rainfall event in late January caused a major reversal in water level through February, triggering widespread nest abandonment of the early nesting species (WOST, ROSP, and GREG). A return to previous recession rates and depths in March and April allowed for a moderate nesting response from WHIB, SNEG, and TRHE, which nest later in the season.

Long-Term Trends

To understand the status of wading bird populations and how they are responding to climatic conditions, water management, and restoration efforts, it is important to consider the long-term (decadal and longer) trends in nesting responses. Long-term data reveal that several nesting responses have improved over the past 20 years, while others have shown no change or are getting worse. In short, numbers of WHIB, WOST, and GREG nests have increased over the past 20 years and appear to frequently meet restoration targets (**Table 1**). Moreover, the interval between exceptional WHIB nesting years has met the restoration target (<2.5 years) for 11 of the past 12 years. There have been some recent improvements in the number of birds nesting at historical coastal colonies, but the proportion remains below the 50% restoration target (5-year running average of 24.8%).

Several measures are not improving and are cause for concern. Despite slight improvements in recent years, the numbers of SNEG, TRHE, and LBHE have been declining sharply (**Figure 2**), and the causes of the declines are unknown. Also, despite improved WOST nesting effort, the late timing of their nesting (with the exception of the last 3 years) has remained relatively static and their nesting success often is below that necessary to sustain the local population. The ratio of tactile (WOST, WHIB, and ROSP) to visual (herons and egrets) foragers has improved since the mid-2000s but remains an order of magnitude below the restoration target. For more information on Everglades restoration performance measures, see the *Status of Wading Bird Recovery* section at the end of this report.

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Abbreviations

Bird Species: American Flamingo (AMFL, *Phoenicopterus ruber*), Anhinga (ANHI, *Anhinga anhinga*), Bald Eagle (BAEA, *Haliaeetus leucocephalus*), Black-crowned Night Heron (BCNH, *Nycticorax nycticorax*), Brown Pelican (BRPE, *Pelecanus occidentalis*), Cattle Egret (CAEG, *Bubulcus ibis*), Cape Sable Seaside Sparrow (CSSS, *Ammodramus maritimus mirabilis*), Double-crested Cormorant (DCCO, *Phalacrocorax auritus*), Glossy Ibis (GLIB, *Plegadis falcinellus*), Great Blue Heron (GBHE, *Ardea herodias*), Great Egret (GREG, *Ardea alba*), Great White Heron (GWHE, *Ardea herodias occidentalis*), Green Heron (GRHE, *Butorides virescens*), Little Blue Heron (LBHE, *Egretta caerulea*), Magnificent Frigatebird (MAFR, *Fregata magnificens*), Neotropic Cormorant (NECO, *Phalacrocorax brasilianus*), Osprey (OSPR, *Pandion haliaetus*), Reddish Egret (REEG, *Egretta rufescens*), Roseate Spoonbill (ROSP, *Platalea ajaja*), Snowy Egret (SNEG, *Egretta thula*), Tricolored Heron (TRHE, *Egretta tricolor*), White Ibis (WHIB, *Eudocimus albus*), Wood Stork (WOST, *Mycteria americana*), Yellow-crowned Night Heron (YCNH, *Nyctanassa violacea*), Unidentified Small White Herons (SMWH, either Snowy Egret or juvenile Little Blue Heron), Unidentified Small Dark Herons (SMDH, either Little Blue Heron or Tricolored Heron)

Regions, Agencies, and Miscellaneous: Arthur R. Marshall (A.R.M.), c/n = chicks per nest, Charlotte Harbor Aquatic Preserves (CHAP), Comprehensive Everglades Restoration Plan (CERP), Corkscrew Regional Ecosystem Watershed (CREW), Everglades National Park (ENP), Florida Department of Environmental Protection (FDEP), Kissimmee River Restoration Evaluation Program (KRREP), National Geodetic Vertical Datum of 1929 (NGVD29), National Wildlife Refuge (NWR), North American Datum of 1983 (NAD83), Restoration Coordination and Verification (RECOVER), South Florida/Caribbean Inventory and Monitoring Network (SFCN), South Florida Water Management District (SFWMD), standard deviation (SD), Water Conservation Area (WCA), Water Year (WY)

HYDROLOGIC PATTERNS FOR WATER YEAR 2019

WATER CONSERVATION AREAS AND NORTHEAST SHARK RIVER SLOUGH HYDROLOGY

Annual rainfall totals and annual mean water depth stages in the Everglades Protection Area during Water Year 2019 (WY2019) were close to average historical conditions. Rainfall for the year was 2.0 inches above historical averages in Water Conservation Areas (WCAs) 1 and 2, 2.2 inches below average in WCA-3A, and 0.8 inches above average in Everglades National Park (ENP). Annual average stage was 0.6 feet above historical average in WCA-1, 0.2 feet above average in WCA-2, and comparable to average in WCA-3 (**Table 2**).

Water depths at the beginning of WY2019 (May 2018) were relatively high because of the early onset of the wet season, but lower than average summer rainfall resulted in low stages at the peak of the wet season (October 2018) and the early part of the WY2019 dry season (November 2018 to January 2019; **Figure 3**). The relatively short hydroperiod and a small spatial extent of flooded marsh (compared to the average) likely limited wading bird prey availability because such hydrologic conditions generally are associated with decreased fish production (Trexler et al. 2005). The second half of the dry season experienced a series of rainfall-driven reversals resulting in above-average stages within most regions of the Everglades (**Figure 3**). Rising water levels reduced accessibility of prey to foraging wading birds (prey concentrated at high densities in shallow pools re-disperse into the wider landscape) and led to relatively limited nesting effort and success in WY2019. Hydrologic conditions in WY2019 contrast sharply with those in WY2018, which were optimal for wading bird nesting and resulted in nesting efforts comparable to the pre-drainage period of the 1930s and 1940s.

Due to the unusually high rainfall and a subsequent rapid rise in stages early in WY2019, the U.S. Army Corp of Engineers issued a temporary deviation to address high-water concerns in the Everglades that allowed for higher water levels in WCA-2A. In addition, the Florida Fish and Wildlife Conservation Commission issued an executive order in June 2018 restricting public access to WCA-2A and WCA-3A. **Figures 3A** through **3G** present hydropatterns at select gauges, highlighting the average stage changes in the WCAs for the last 2.5 years. The figures relate water levels to historical averages, flooding tolerances for tree islands, drought tolerances for wetland peat, and recession rates and depths that support foraging and nesting needs of wading birds during the breeding season. The South Florida Water Management District (SFWMD) uses these indices as part of the ecological recommendations to water managers at weekly interagency water operations meetings. Tree island inundation tolerances are considered exceeded when depths on the islands are above 2.0 or 2.5 feet, depending on the height of the tree islands, for longer than 120 days (Wu et al. 2002). Lower islands are inundated at lower high-water levels (i.e., 2.0 feet versus 2.5 feet). The ground elevations in **Figures 3A** through **3G** (in feet National Geodetic Vertical Datum of 1929 [NGVD29]) are used to indicate the threshold for peat conservation. When water levels are more than 1 foot below ground for more than 30 days, the drought tolerance of peat is considered exceeded according to the criterion for the Everglades Minimum Flow and Minimum Water Level (MFL; SFWMD 2014). However, peat soils may be damaged at water levels shallower than stipulated in the MFL.

The wading bird nesting period ranges from November through June each year. Wading bird habitat suitability is determined by water depths and recession rates and is divided into three categories (poor, moderate, and good) according to recent research on foraging requirements of wading birds in the Everglades (Gawlik 2002; Beerens et al. 2011, 2015; Cook 2015). A green arrow on the hydropattern figures indicates a period with good recession rates and depths for wading birds. A yellow arrow indicates water levels that are too shallow or too deep and/or recession rates that are slightly too rapid or too slow. A red arrow indicates poor conditions, resulting from water depths that are too high or low and/or unsuitable recession rates (rising or falling too rapidly).

Water Conservation Area 1

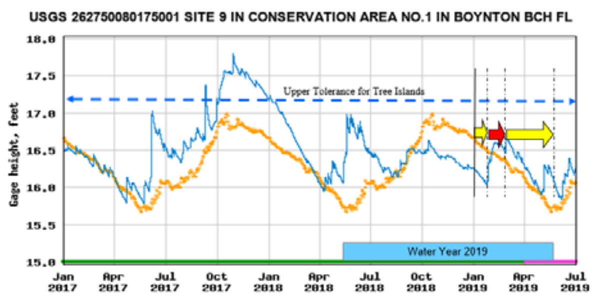
The water level in WCA-1 (also called the Arthur R. Marshall Loxahatchee National Wildlife Refuge) at the start of WY2019 was significantly elevated compared to the 25-year daily median (**Figure 3A**). Wet season depths rose quickly, and the stage peaked in June well above the average depth for that month, then remained below average from September to February. Stages were above average during the spring and remained that way until the end of the year. Below-average depth conditions during most of the wet season can lead to below-average prey production for wading birds, and depths were too low at the start of the nesting season for the drawdown to extend throughout the nesting season. The yellow arrows in **Figure 3A** indicate depths during this time were not optimal. The red arrow indicates stage or stage change conditions that did not support wading bird foraging, in this case a significant reversal in falling stage. Wading bird foraging and nesting was minimal in WCA-1; however, larger than average nesting colonies of small herons were evident later in the nesting season along the eastern boundary of WCA-1 after water levels started to decline again. The upper tolerance level or depth for tree islands, above which indicates flooding stress, was not exceeded. Water depths never fell below the lower tolerance band, below which is an indication of potential peat soil loss due to oxidation.

Table 2. Average, minimum, and maximum stage (in feet NGVD29) and total annual rainfall in inches for WY2019 compared to historical water depth stages and rainfall.[a] (Average depths calculated by subtracting elevation from stage.)

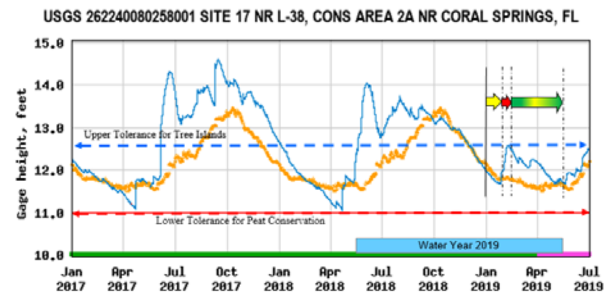
Area	WY2019 Rainfall (inches)	Historical Rainfall (inches)	WY2019 Stage Mean (min.; max.)	Historical Stage Mean (min.; max.)	Elevation
WCA-1	53.97	51.96	16.37 (15.87; 16.96)	15.70 (10.0; 18.16)	15.1
WCA-2	53.97	51.96	12.71 (11.68; 14.03)	12.51 (9.33; 15.64)	11.2
WCA-3	49.07	51.24	9.62 (4.78; 12.79)	9.60 (4.78; 12.79)	8.2
ENP, Slough at P33	55.30	54.55	6.46 (5.55; 7.44)	6.05 (2.01; 8.08)	5.1

a. Historical averages are based on varying lengths of records at gauges.

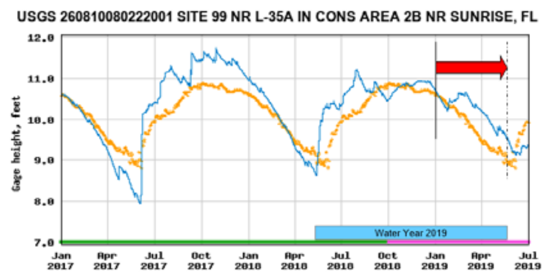
A. WCA-1 – Site 9



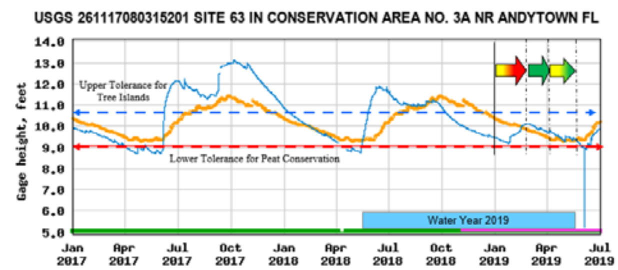
B. WCA-2A – Site 17



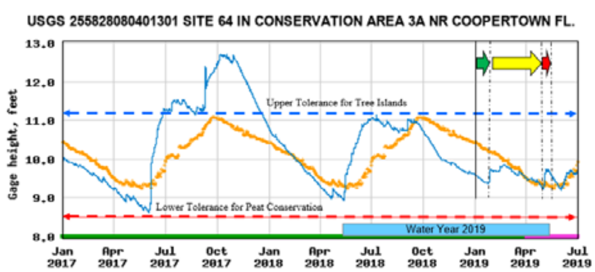
C. WCA-2B – Site 99



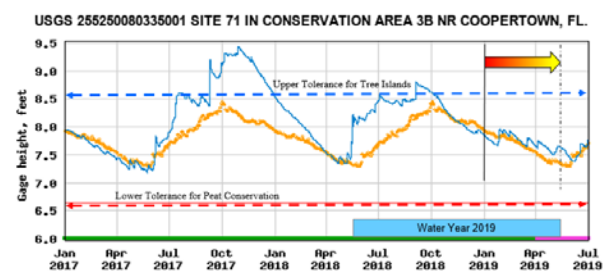
D. WCA-3A – Site 63



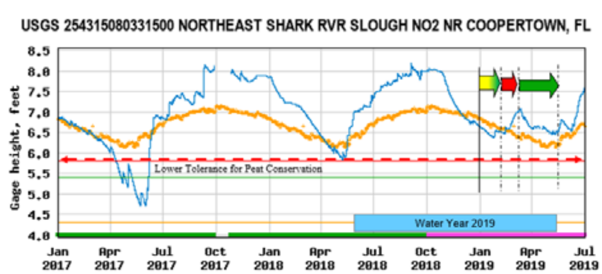
E. WCA-3A – Site 64



F. WCA-3B – Site 71



G. Northeast Shark River Slough



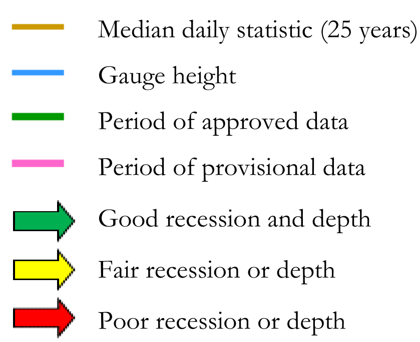


Figure 3. Hydrology in the WCAs and ENP in relation to average water depths (A: 25-year average, B: 25-year average, C: 24-year average, D: 24-year average, E: 26-year average, F: 25-year average, G: 34-year average), and indices for tree island flooding, peat conservation, and wading bird foraging.

Water Conservation Area 2A

As in most other parts of the Everglades (except WCA-1), water depths in WCA-2A were close to the long-term average at the start of the WY2019 wet season and rose rapidly above the average stage immediately thereafter and through the first half of June. The maximum depth for the water year at Site 17 was attained on June 6, 2018. Depths then fell to the long-term average by October and remained near average until a large rain event in late January 2019 caused a reversal in water levels. Hydrologic conditions in WCA-2A generally were conducive to wading bird foraging (wet antecedent conditions followed by a long period of optimal recession rates), which explains the relatively large numbers of foraging birds noted in this area. Recession rates were good for wading birds starting in October, but depths generally were low for foraging by the start of the dry season (yellow arrow in **Figure 3B**). A large reversal in water level recession prevented foraging for a few weeks but allowed for moderate foraging towards the end of the nesting season. Stages exceeded the upper flood tolerance for tree islands from June through December. WCA-2A stages did not drop below the lower tolerance level for peat conservation.

Water Conservation Area 2B

Unlike the rest of the Everglades, WCA-2B tends to be too deep for foraging most of the year (**Figure 3C**). During WY2019, water depths at gauge 99 began near the historical average, rose rapidly and peaked in late July, then declined and generally followed just above the 24-year average. The red arrow in **Figure 3C** signifies water levels were too deep to support wading bird foraging.

Water Conservation Area 3A

Water levels in northeastern WCA-3A, at gauge 63, during WY2019 began below the historical average (**Figure 3D**) and below the lower tolerance for peat conservation. As in other parts of the Everglades, water levels rose quickly in the early wet season and peaked in mid-June near 10.4 feet NGVD29, more than 2.5 feet lower than the peak stage in WY2018. Prior to the nesting season, foraging conditions were optimal and large flocks of birds were noted in this region; however, depths fell well below average during the nesting season such that foraging habitat was no longer available (the red arrow in **Figure 3D**). As in the other WCAs, a rain-driven increase in water level during late January raised depths considerably, which reduced prey availability and led to nest abandonment.

The hydrologic pattern in central WCA-3A, at gauge 64 (**Figure 3E**), was very similar to that at gauge 63. Water levels peaked in July, went below average in September, and remained so until the reversal in January pushed depths up to near average. The relatively poor conditions meant that Wood Storks (WOST) did not nest in their traditional rookeries in central WCA-3A during WY2019.

Water Conservation Area 3B

Water levels at site 71 in WCA-3B began WY2019 near the historical average (**Figure 3F**). Stage climbed quickly but, instead of peaking early like in other WCAs, continued to climb until September. Stage fell to average by October, meaning that water depth at gauge 71 exceeded the upper tolerance for tree islands during the month of September. Conditions were poor in WCA-3B for wading bird foraging during most of the wading bird nesting season due to repeated reversals in water level. The multi-colored arrow in **Figure 3F** indicates poor foraging conditions as depths in the early nesting season were too deep for wading bird foraging and reversals prevented foraging later in the dry season.

Northeast Shark River Slough

At the start of WY2019, water levels in Northeast Shark River Slough were just below the historical average (**Figure 3G**) and near the lower tolerance for peat conservation. Water levels rose dramatically, peaking above 8.0 feet NGVD29 in September. This is the third year in a row and only the fourth time in the last 20 years (WY2018, WY2017, and WY1999) that stage here has exceeded this depth. Depths remained above the historical average until December. The multi-colored arrow at the beginning of the nesting season in **Figure 3G** indicates fair depth conditions as recession rates were high, transitioning to optimal until a series of reversals starting in January caused large-scale abandonment of the WOST and Great Egrets (GREG) nesting in the coastal colonies of ENP. Post-reversal recession rates and depths were near optimal for wading bird foraging at this location beginning in March and continuing through the remainder of the nesting season. This led to relatively large numbers of White Ibis (WHIB) and small herons nesting in the coastal colonies towards the end of the nesting season.

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REGIONAL NESTING REPORTS

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

The University of Florida Wading Bird Project continued its long-term monitoring of wading bird reproduction throughout Water Conservation Areas (WCAs) 2 and 3 and Arthur R. Marshall (A.R.M.) Loxahatchee National Wildlife Refuge (also called WCA-1) in 2019. Monitoring focused primarily on counts for Great Egret (GREG), White Ibis (WHIB), Snowy Egret (SNEG), and Wood Stork (WOST), the species that serve as bioindicators for the Comprehensive Everglades Restoration Plan (CERP) and are most readily located and identified through aerial searches. Estimates for these and other species were gleaned from aerial and systematic ground surveys as well as visits to nesting colonies and more intensive studies of nest success.

METHODS

Aerial and ground surveys were performed in 2019 to locate and characterize nesting colonies. On or around the 15th of each month from January through June, aerial surveys were performed to find active colonies using observers seated on both sides of a Cessna 182. Surveys were conducted from an altitude of 800 feet above ground level along east-west oriented flight transects spaced 1.6 nautical miles apart. These techniques have been used since 1986, and they result in overlapping coverage during a variety of weather and visibility conditions. In addition to contemporaneous visual estimates of nesting birds by the two observers, digital aerial photos were taken of all colonies, and nesting birds in the photos were counted. The reported numbers of nest starts were derived from a combination of information sources, including peak estimates of nests in any colony, supplemental information from monthly South Florida Water Management District helicopter surveys staggered by 2 weeks from the University of Florida survey, ground visits, and inference from observations across the season.

Michael Baranski

Since 2005, systematic ground surveys have been performed in parts of WCA-3 that give an index of abundance for small colonies and dark-colored species that are not easily located during aerial surveys. During ground surveys, all tree islands within sixteen 500-meter wide belt transects (covering 336 km^2) were approached closely enough to flush nesting birds, and nests were counted directly if visible or estimated from flushed birds. The totals were added to the numbers derived from aerial estimates. Because ground surveys were conducted on a subset of the total area, the resulting nest estimates should be used mainly for year-to-year comparisons and reflect minimum estimates for the total number of nesting pairs of Little Blue (LBHE), Tricolored (TRHE), and Great Blue (GBHE) herons.

MARK COOK

In 2019, an unmanned aerial vehicle (UAV) was used to supplement current aerial sampling method for large and mixed species colonies. UAV flights were conducted over certain colonies to confirm nest starts and colony abandonment. On April 13, a UAV survey was conducted of the region's largest colony, Alley North. Based on other aerial surveys and ground observations at the time, this appeared to be close to the peak of incubation for WHIB, throughout the colony. A DJI Inspire II quadcopter, fitted with a Zenmuse X7 35-mm equivalent camera lens, was used for the survey. Images captured via UAV were from an altitude of 300 feet above ground level, were shot at an angle of 10° from nadir, and included more than 75% overlap in all four directions. The images were stitched together using AgiSoft software on a 10-core computer and counted manually by a single observer using Photoshop to mark targets counted.

RESULTS

Nesting Effort

Initially low water levels followed by rainfall events in January, February, and March led to a late start to the nesting season for most species. Large numbers of GREG were present in many colonies in January, but nesting was not initiated until late March. This was 1.5 to 2 months late and probably the latest recorded initiation for GREG in the last 15 years. Small herons and WHIB also began nesting in late March and continued into April and May. Although early to mid-March is more common for initiation by these species, this was within the range of nesting dates recorded in the last 20 years.

An estimated 18,409 wading bird nests were initiated at colonies within WCA-1, WCA-2, and WCA-3 in 2019 (**Tables 3** and **4**). With the exception of a large WHIB and small heron colony in WCA-3A (Alley North), the majority of nesting occurred in WCA-1. Overall, this was a poor nesting season; the total number of nests was 62% of the 10-year average nesting effort and 56% of the 5-year average. Nesting effort for GREG and WOST accounted for much of this difference. GREG nesting effort was the lowest in the last 19 years, 28% of the 10-year average and 30% of the 5-year average. Despite two previously successful nesting seasons, WOST were not observed nesting in the WCAs in 2019. WHIB nesting effort was also low, 51% of the 10-year average and 42% of the 5-year average. SNEG were the exception, with above-average nesting effort at 4.2 times the 10-year average and 4.0 times the 5-year average, and mostly were observed in WCA-1.

Table 3. Number of nesting pairs found in A.R.M. Loxahatchee National Wildlife Refuge (WCA-1) during systematic surveys, February through June 2019.

Colony	Latitude	Longitude	GREG	WHIB	ROSP	SNEG	GBHE	LBHE	TRHE	Unidentified Small White	ANHI	Colony Total
Cook NC1 (77/78)	26.55370	-80.25080				424		+				**424**
Cook NC2 (76)	26.46333	-80.24445				346		+				**346**
Cook NC4	26.53280	-80.27617	44	167								**211**
Lox Ramp/011	26.49511	-80.22533	49	630	2	124		+	+		+	**805**
Lox 99	26.43822	-80.39053	182	667				+		600		**1,449**
Lox West	26.55014	-80.44268	22		4		2	+		648	+	**676**
Lox 73/Tyr	26.37187	-80.26597	27			44		+				**71**
Utu	26.37197	-80.31035	67				3					**70**
38/185	26.44892	-80.24226	57									**57**
43	26.51123	-80.43767	13			84		+				**97**
63/006	26.61690	-80.30672				89		+				**89**
71	26.53965	-80.23400				545		+				**545**
74	26.12793	-80.83481	5			125		+	+			**130**
75	26.60782	-80.29647				732		+	+		+	**732**
Colonies >50 nests			466	1,464	6	2,513	5	0	0	1,248	0	**5,702**
Colonies <50 nests			70	0	0	0	0	0	0	0	0	**70**
Total by Species			**536**	**1,464**	**6**	**2,513**	**5**	**0**	**0**	**1,248**	**0**	**5,772**

Note: WOST, GLIB, BCNH, CAEG, YCNH, unidentified large white birds, and unidentified small dark birds were not observed (count = 0).
+ Present but not counted.

Table 4. Number of nesting pairs found in WCA-2 and WCA-3 during systematic surveys, February through June 2019.

Colony	WCA	Latitude	Longitude	GREG	WHIB	ROSP	SNEG	GBHE	LBHE	TRHE	BCNH	Unidentified Small White	ANHI	Colony Total*
6th Bridge	3	26.12428	-80.54148	165		50	9							**224**
Alley North	3	26.20132	-80.52873	250	8,486	30	137	13	+	+		1,472	+	**10,388**
Diana	3	25.84727	-80.52347	126										**126**
Rhea	2	26.23782	-80.31280	126			58		+	+				**184**
576	3	25.97969	-80.75636				45		30	8	4			**87**
610/67 NC 2018	3	25.91348	-80.80869				25		25	4	1			**55**
739	3	25.93638	-80.78195				13		52	5				**70**
766/57 NC 2018	3		-80.77228				25		33	7	1			**66**
Colonies >50 nests				667	8,486	80	312	13	140	24	6	1,472	0	**11,200**
Colonies <50 nests**				296	0	5	21	146	29	17	911	12	526	**1,963**
Total by Species				**963**	**8,486**	**85**	**333**	**159**	**169**	**41**	**917**	**1,484**	**526**	**13,163**

Note: WOST, GLIB, CAEG, YCNH, unidentified large white birds, and unidentified small dark birds were not observed (count = 0).
+ Present but not counted.
* Excludes ANHI.
** Includes count of wading bird nesting pairs from ground surveys.

Roseate Spoonbills (ROSP) nested at Jetport South, Hidden, Henry, 6th Bridge, Alley North, Cypress City, Lox West, and Lox Ramp (91 nests total) this season. Overall, this was a poor nesting effort for ROSP, 71% of the 10-year average and 57% of the 5-year average. This follows the recent trend of nesting effort by ROSP in the WCAs, and nest success likely was poor.

This season showed a continued declining trend in *Egretta* heron nesting effort, with 37 TRHE and 144 LBHE nests observed during systematic ground surveys. Compared to average nesting between 1996 and 2007, the average number seen between 2007 and 2019 declined 78% for LBHE and 83% for TRHE. However, there was an uptick in LBHE nesting effort in 2019, with 1.3 times the 5-year average, but still far below the overall average. While few TRHE nests were observed during systematic ground surveys, large numbers of nesting TRHE were observed in flight lines at Alley North in early June. This pattern could be the result of a general reduction in nesting by these species throughout the Everglades, or it could indicate that these species are nesting elsewhere in the system such as in larger colonies or in coastal areas. Logistically, *Egretta* herons are difficult to count in large colonies. However, large numbers of nesting LBHE and branchlings were observed in WCA-1, where SNEG also nested in high numbers. Competing predictions about the declines are being addressed, such as a decline or shift in composition of the prey base, displacement by Black-crowned Night Herons (BCNH), or movement to coastal colonies. BCNH are likely to predate nestlings of *Egretta* herons, have been increasing as nesters during the past 10 years, and were observed in high numbers (1.3 and 1.1 times the 5- and 10-year averages, respectively) during systematic ground surveys in 2019, despite overall poor nesting effort of other wading birds.

Reproductive Success

Nest success was monitored at two colonies: one in WCA-3B (Diana) and one in WCA-3A (Alley North). Individual nests of GREG (n = 43 at Diana) and WHIB (n = 150 at Alley North) were monitored through ground-based nest checks every 5 to 7 days throughout the nesting season. Four other colonies were visited on foot in WCA-3A (Henry, Cypress City, Hidden, and 6th Bridge) to verify nest starts and failures. Aerial surveys via UAV and fixed-wing airplane were used to confirm systemwide colony abandonment in WCA-2 and WCA-3.

Nest success (P; probability of fledging at least one young, Mayfield method) was determined for WHIB (P = 0.189; SD = 0.032). While incubation success was low (P = 0.240; SD = 0.037), WHIB fledgling success was relatively high (P = 0.787; SD = 0.052), suggesting a small cohort of fledged WHIB chicks were produced in 2019. In late March, 43 GREG nests were marked at Diana, with an average clutch size of 2.14. By the following colony visit, 38 of the 43 nests had failed. Aerial and drone surveys confirmed total colony failure, and no subsequent nesting attempts were recorded. Additionally, four GREG nests with one to two eggs each were marked at 6th Bridge, but these nests failed shortly thereafter. No other species were observed nesting. In early April, 11 empty GREG platforms with broken eggs beneath were observed at Hidden during a ground visit to confirm colony failure. One active ROSP nest was observed with three eggs and an adult present; however, no wading birds were observed in subsequent aerial surveys. Eight empty GREG platforms and two nests with two eggs each were observed at Cypress City. This colony was also abandoned, and no further nesting attempts were made. Aerial and ground observations suggest no GREG nests fledged in WCA-3A in 2019. However, large GREG chicks and fledglings were observed in several colonies in WCA-1 and one colony (Rhea) in WCA-2.

A relatively consistent yet short dry down pattern through April and May allowed most small herons and WHIB to successfully fledge chicks as late as mid-June. However, conditions were not conducive for GREG, WOST, and ROSP, which require longer reproductive periods.

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EVERGLADES NATIONAL PARK

Mainland

This summary report addresses colony monitoring within the slough and estuarine areas of Everglades National Park (ENP) using data collected during the 2019 wading bird breeding season. Wading bird nesting colonies in ENP are surveyed as part of a regional monitoring program to track wading bird nesting effort and success throughout the greater Everglades ecosystem. Data collected during surveys and monitoring flights help guide ongoing ecosystem restoration projects. The long-term monitoring objectives for wading bird nesting colonies in ENP are as follows:

- Collect data on locations of wading bird colonies, numbers of nests, timing of nesting, and nesting success.
- Compile and share data with other agencies that monitor wading birds in South Florida, with the ultimate goal of restoring and sustaining wading bird populations in the Everglades.

Methods

Airplane or helicopter surveys of known colony locations were conducted from December 2018 to September 2019. Flight dates were December 17, 18, and 19; January 18 (University of Florida conducted this flight of the ENP mainland colony sites during the federal government shutdown); February 12, 19, and 22; March 20, 21, and 22; April 1, 2, 16, and 17; May 22; June 26; July 12; August 15; and September 4. Mainland colony flights often were combined with Florida Bay waterbird surveys or alligator nesting surveys. Flight altitude was maintained at 600 to 800 feet above ground level during the surveys. During each flight, visual estimates of nest numbers by species were made and photos were taken using a digital SLR camera with a 100-400 mm lens. Photos were compared to visual estimates to assist with determining nest numbers, nesting stage, and species composition.

A systematic reconnaissance colony survey was conducted on April 1 and 2 across slough and estuarine habitat within ENP to locate new colonies. Two observers, one sitting on each side of a Cessna 206 high-wing float aircraft, searched for colonies along 20 established transects oriented east to west and spaced 1.6 nautical miles apart. Flight altitude was maintained at 800 feet above ground level throughout the survey. Coordinates of colony locations were recorded, and photos were taken of colony sites. Species monitored included Great Egret (GREG), Wood Stork (WOST), White Ibis (WHIB), Snowy Egret (SNEG), Roseate Spoonbill (ROSP), Tricolored Heron (TCHE), and Little Blue Heron (LBHE). Other birds that may be found nesting in the colonies, such as the Great Blue Heron (GBHE), Black-crowned Night Heron (BCNH), and Cattle Egret (CAEG), were noted as well.

Results

Nesting effort in ENP did not approach the outstanding numbers seen during the 2018 nesting season, yet it was still the third largest initial nesting event recorded in ENP in more than 20 years, mostly due to higher numbers of nesting WHIB. Unfortunately, and despite the ambitious initial nest effort, all WOST nests and most GREG nests failed.

An estimated 13,499 wading bird nests were initiated in ENP (**Table 5**), which was comparable to the high numbers seen during the 2009 (14,229 nests) and 2013 (12,505 nests) nesting seasons. The bulk of nesting birds were WHIB at four colony sites, with most at the Cabbage Bay site (2018 supercolony). A total of 16 wading bird colonies were active this season, compared to 37 in 2018 (**Figure 4**). Of the 16 colonies, 3 were transient smaller GREG colonies in Shark River Slough.

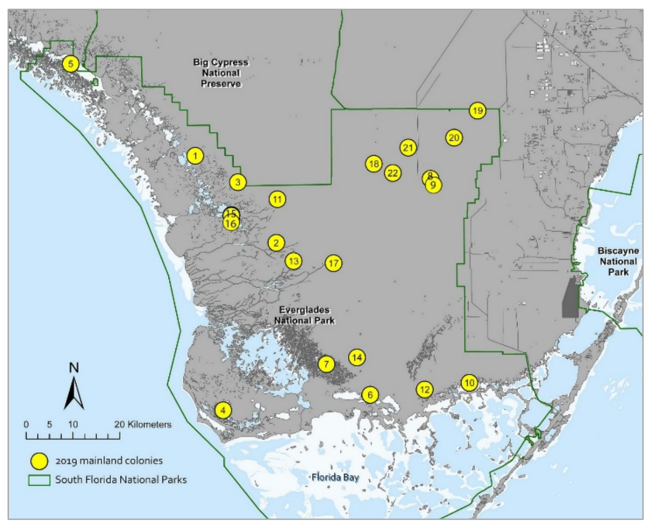

Figure 4. Active wading bird nesting colonies in ENP, 2019. **Table 5** contains the colony names and details.

The first flight to check mainland colony sites was conducted on December 17 and 18. At Cabbage Bay, WOST were standing on 23 nearly finished nests. At Broad River, 115 WOST were standing in the colony area. Some WOST were paired and working on new nests but none were incubating eggs yet. The Tamiami West colony site had a few roosting GREG and two WOST, but none were actively nesting. Other colony sites were not yet active.

Table 5. Peak numbers of wading bird nests found in ENP colonies from December 17, 2018 through September 4, 2019.

Map ID	Site Name	Latitude	Longitude	GREG	WOST	WHIB	SNEG	ROSP	TRHE	LBHE	Total
1	Alligator Bay	25.67099	-81.14714	85		400			+	+	**485**
2	Broad River[1]	25.50292	-80.97440	100	550		10	29	+	+	**689**
3	Cabbage Bay[1]	25.62000	-81.05612	90	190	9,400	+	8	+	+	**9,688**
4	Cape Sable[2]	25.17965	-81.08711								**0**
5	Chokoloskee Bay Lane Cove	25.84808	-81.41297								**0**
6	Cuthbert Lake	25.20933	-80.77500	63							**63**
7	East River	25.26860	-80.86785	25							**25**
8	Grossman Ridge West	25.63627	-80.65275	45							**45**
9	Grossman Ridge Willowhead	25.62613	-80.64582	38							**38**
10	Diamond Key, Joe Bay[3]	25.23205	-80.56455	175				16	40		**231**
11	Lostmans Creek	25.58723	-80.97204								**0**
12	Madeira Hammock[3]	25.21932	-80.65945								**0**
13	Otter Creek	25.46780	-80.93772	175		800		+	+	+	**975**
14	Paurotis Pond[3]	25.28150	-80.80300	200	170	500	10	83	40	+	**1,003**
15	Rodgers River Bay Large Island	25.55667	-81.06984	19							**19**
16	Rodgers River Bay Small Island	25.55522	-81.06998								**0**
17	Rookery Branch[1]	25.46356	-80.85256	131							**131**
18	Shark Valley Tower	25.65538	-80.76652								**0**
19	Tamiami West[1]	25.75745	-80.54502	29	12			1			**42**
20	2019 GREG Colony 1	25.70548	-80.59531	20							**20**
21	2019 GREG Colony 2	25.68657	-80.69320	25							**25**
22	2019 GREG Colony 3	25.63759	-80.72615	20							**20**
	Total			**1,240**	**922**	**11,100**	**20**	**137**	**80**	**+**	**13,499**

Note: GBHE were not observed (count = 0).
+ Species present and nesting, but unable to determine number of nests.
[1] Data from the University of Florida and ENP.
[2] Data from Audubon Florida.
[3] Data from Audubon Florida and ENP.

During the December 22 to January 25 federal government shutdown, biologists from the University of Florida's Department of Wildlife Ecology and Conservation checked the ENP colony sites. On the January 18 survey, the university biologists found that most of the larger colony sites were active with GREG and WOST nests, some WOST were incubating, and a few WOST nests at the Broad River colony contained one egg. After a late January rain event and water level reversal, all WOST in ENP abandoned their nests. When checked again on February 22, only GREG and a few ROSP were present and still nesting. At some point, most WOST returned to existing nests at Paurotis Pond, Broad River, and Cabbage Bay. On March 20, the majority of WOST were incubating, and two eggs were seen in several nests. After another rain event and water reversal in early April, WOST abandoned their nests a second time. On April 16, all ENP WOST nests were empty, except for two nests at Paurotis Pond, each with an adult still sitting on the nest. When checked again in May, these nests also were empty.

GREG also were affected by water level reversals this season. They were unusually asynchronous in their initial nesting, and most of their nests later failed. The earliest nesting birds were seen in January, but many others were incubating on nests in March (most colony sites) and some birds were incubating in May (at Paurotis Pond). During the March, May, and June flights, many nests were empty and abandoned. In May and June, very few chicks were seen; most nests had been abandoned at some point.

WHIB made up the bulk of nesting birds in ENP this season and most appeared to have been successful. They were first seen roosting at Cabbage Bay and Otter Creek in March. In April, they were sitting on nests at both sites as well as at Alligator Bay and Paurotis Pond. In May, many thousands of fledged WHIB chicks were seen roosting at Cabbage Bay and many hundreds more were at both Otter Creek and Paurotis Pond. On July 23, another group of approximately 800 WHIB were nesting at Cabbage Bay, but they were gone when checked again on August 15.

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ROSEATE SPOONBILL NESTING IN FLORIDA BAY

METHODS

Historically, Roseate Spoonbills (ROSP) have used 61 keys in Florida Bay and 3 mainland colony sites adjacent to Florida Bay for nesting (**Figure 5**). These colonies are divided into five distinct nesting regions based on the primary foraging locations used by the birds (**Figure 5**; **Table 6**; Lorenz et al. 2002). During the 2018-2019 nesting season (November 2018 through June 2019), complete nest counts were performed in all five regions of the bay by entering the colonies and thoroughly searching for nests. Eighteen colonies were found to have ROSP nesting activity, including solitary nests found in southeastern Bear Lake and in an area just north of Slagle's Ditch on Cape Sable.

Nest production was estimated using two methods. The preferred method was to perform mark-and-revisit surveys at active colonies within each region to estimate nest success. These surveys involved marking as many nests as possible shortly after full clutches had been laid, and then revisiting the colonies on a 10- to 21-day cycle. Nests were monitored until failure or until all surviving chicks reached at least 21 days of age, which is when chicks begin branching and can no longer be assigned to a nest. A colony was considered successful if it averaged at least one chick to 21 days per nesting attempt (c/n). If revisits placed chicks (ROSP or other species) in danger or could not be performed because of logistical reasons (e.g., water levels were too low to access the colony), flighted young of the year (they conspicuously roost in the colony tree tops) prior to fledging from the island were counted, and the maximum observed number was used. Mean laying and hatching dates refer to the first egg laid and hatched in each clutch. Results are presented in the context of the target metrics found in the Stoplight Report for the Northeast and Northwest regions (Lorenz et al. 2009). The Southeast and Central regions are compared using 1984 as a baseline; 1984 was the year the South Dade Conveyance System was completed, which has direct water management implications on Florida Bay and has impacted ROSP nesting activity within the bay (Lorenz et al. 2002, Lorenz 2014). The Southwest region typically uses 1984 as a baseline as well; however, no nests were verified in this region in 2019.

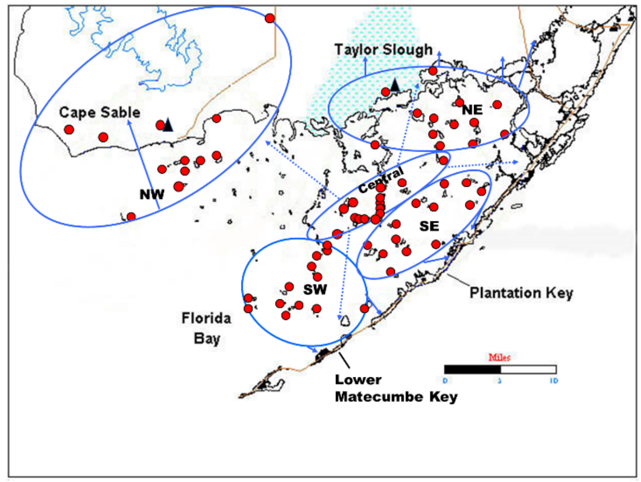

Figure 5. Map of Florida Bay, indicating ROSP colony locations surveyed in 2018-2019 (red dots), hydrostations (black triangles), and nesting regions (blue circles). Arrows indicate the primary foraging area for each region. The dashed lines from the Central region are speculative.

Table 6. Number of ROSP nests in Florida Bay, November 2018 through May 2019, with minima, mean, and maxima summary data since 1984-1985.

Region	Colony	Latitude	Longitude	Number of Nests	Minimum	Mean	Maximum	Number of Years with Nesting since 1984-1985	Number of Years Monitored
Northeast	Diamond	25.23200	-80.56450	16	0	5.4	16	3	5
	Duck	25.18012	-80.48929	7	0	12.1	100	18	31
	Eagle	25.16797	-80.59631	1	0	2.7	8	5	7
	Northeast Region Subtotal			**24**	**3**	**146.3**	**333**	**--**	**--**
Northwest	Sandy	25.03470	-81.01396	23	6	117.6	250	34	34
	Palm	25.11753	-80.87995	82	0	36.4	100	15	16
	Oyster	25.10391	-80.95151	13	0	5.1	45	14	28
	Paurotis Pond	25.28262	-80.80255	83	2	45.4	128	14	14
	Slagle's Ditch	25.14400	-81.02930	1	0	1.0	1	1	1
	Bear Lake	25.16135	-80.95100	1	0	1.0	1	1	1
	Northwest Region Subtotal			**203**	**65**	**196.5**	**325**	**--**	**--**
Central	Calusa	25.05887	-80.69472	1	0	6.8	21	15	19
	Captain	25.02664	-80.63205	8	0	4.8	25	7	13
	Central Jimmie	25.05199	-80.64488	7	0	14.0	47	25	29
	First Mate	25.02677	-80.64631	6	0	2.5	15	9	13
	North Jimmie	25.06626	-80.64292	5	0	1.8	12	4	11
	Central Region Subtotal			**27**	**3**	**42.7**	**96**	**--**	**--**
Southeast	Bottle	25.06366	-80.55582	**1**	0	7.7	40	18	28
	Stake	25.05669	-80.58723	4	0	4.5	19	17	27
	Low	25.05090	-80.57964	4	0	0.6	9	4	27
	Middle Butternut	25.08424	-80.51649	9	0	13.9	66	26	29
	Pigeon	25.05595	-80.51119	10	0	9.0	56	18	27
	Southeast Region Subtotal			**28**	**4**	**54.0**	**117**	**--**	**--**
Florida Bay Total				**282**	**112**	**445.8**	**880**	**--**	**--**

RESULTS

Northeast Region

There were 3 active colonies in the Northeast region this year, producing an estimated total of 24 nests, well below the target metric of 688 nests. Of the 3 colonies, Diamond Key produced the highest total with 16 nests (**Table 7**). Although low, this is the largest count at this colony since monitoring began in 2014-2015. The estimated 0.13 c/n for the region is well below the target 1.39 c/n. The mean lay date was February 11, and the mean hatch date was March 4 (**Table 7**).

Northwest Region

A total of 203 nests from 4 colonies were observed throughout the Northwest region, just 7 nests shy of the target 210 nests and slightly above the average since 1985-1984. Of the five regions, the Northwest provided the largest total number of nests observed. The two largest colonies of any region this season, Palm Key and Paurotis Pond, contributed 82 and 83 observed nests, respectively (**Table 7**). Success was limited. The entire region produced an estimated total of 63 nests with known fates, but only 29 raised at least one chick to 21 days old (**Table 7**). Incidental discoveries of solitary nests inland and outside of known colonies were new for the region. One such nest at Bear Lake succeeded in rearing one chick to fledging. The mean lay date was December 9, and the mean hatch date was December 30 (**Table 7**).

Central Region

The Central region provided a total of 27 nests, with all but 2 successfully monitored to completion. Three of the five colonies with nesting activity failed to produce a single chick to fledging. Of the 8 chicks that survived to 21 days from this region, all but 1 came from Captain Key. The estimated mean production per nest is the lowest on record in the past 10 years at 0.32 c/n. The mean lay date was December 26, and the mean hatch date was January 16 (**Table 7**).

Table 7. Breakdown of colonies, by region, of all monitoring data collected.

Region	Colony	Number of Nests Observed	Number of Marked (Monitored) Nests	Number of Nests Successfully Monitored	Number of Chicks to 21 Days	Estimated Production per Nest	Number of Nests Successful	% Success	Mean Lay Date	Mean Hatch Date
Northeast	Diamond	16	16	8	1	0.13	4	50%	3/21/2019	4/11/2019
	Duck	7	7	6	2	0.33	2	33%	1/3/2019	1/24/2019
	Eagle	1	1	1	0	0.00	0	0%	U/K	U/K
	Region Subtotal	24	24	15	3	0.20	6	40%	2/10/2019	3/3/2019
Northwest	Sandy	23	23	13	20	1.54	11	85%	11/16/2018	12/7/2018
	Palm	82	48	17	25	1.47	13	76%	12/7/2018	12/28/2018
	Oyster	13	13	13	0	0.00	0	0%	11/12/2018	12/3/2018
	Paurotis	83	27	19	4	0.21	4	21%	1/18/2019	2/8/2019
	Slagle's Ditch	1	0	0	U/K	U/K	U/K	U/K	U/K	U/K
	Bear Lake	1	1	1	1	1.00	1	100%	12/22/2018	1/12/2019
	Region Subtotal	203	112	63	50	0.79	29	46%	12/9/2018	12/30/2018
Central	Calusa	1	1	1	1	1.00	1	100%	12/19/2018	1/9/2019
	Captain	8	8	8	7	0.88	5	63%	12/5/2018	12/26/2018
	Central Jimmie	7	7	6	0	0.00	0	0%	1/9/2019	1/30/2019
	First Mate	6	6	6	0	0.00	0	0%	1/4/2019	1/24/2019
	North Jimmie	5	5	4	0	0.00	0	0%	1/1/2019	1/22/2019
	Region Subtotal	27	27	25	8	0.32	6	24%	12/26/2018	1/16/2019
Southeast	Bottle	1	1	1	1	1.00	1	100%	1/15/2019	2/5/2019
	Stake	4	4	2	0	0.00	0	0%	12/21/2018	1/11/2019
	Low	4	4	2	0	0.00	0	0%	1/1/2019	1/22/2019
	Middle Butternut	9	9	6	0	0.00	0	0%	1/12/2019	2/2/2019
	Pigeon	10	10	10	9	0.90	6	60%	12/26/2018	1/16/2019
	Region Subtotal	28	28	21	10	0.48	7	33%	1/2/2019	1/23/2019
Total			282	191	124	71	0.57	48	39%	1/4/2019

U/K = unknown.

* The maximum count of young for the year was 75; however, it is believed this is a severe underestimate of the actual number of fledges. The size and convoluted nature of the colony made it impossible to observe all pre-fledge birds at one time.

** One chick capable of short flights was observed at the colony, but the island had not been monitored since April 10, 2018, so other chicks may have already fledged the island.

Southeast Region

Like the Central region, the Southeast also experienced lower than average nest totals and low success. All 28 observed nests came from 5 colonies, with 21 nests successfully monitored (**Table 7**). Colonies at Stake, Low, and Middle Butternut keys failed to produce any chicks to the fledgling stage. All but 1 of the 10 chicks to reach 21 days old came from Pigeon Key. The mean lay date was January 1, and the mean hatch date was January 23 (**Table 7**).

Southwest Region

Seven colonies were surveyed in the Southwest region. Consistent with the past decade, the only active colony was South Twin Key, where five unverifiable nests were documented in mid-December. Because nests were constructed high in the canopy, the contents were never verified, and subsequent surveys found the nests abandoned. These nests were not included in this count, and no other nesting activity was recorded from the Southwest region.

BAYWIDE SYNTHESIS

The 2018-2019 nesting season produced a total of 282 nests in Florida Bay, almost the same as last year's 278 nests but well below the target metric of 1,258 nests. Throughout the bay, average nest production was 0.56 c/n, with only 35% successfully raising at least one chick to 21 days. The mean lay date of January 4 is the seventh occurrence in the last 8 years when nesting started later than the historical nesting period (November 1 to December 31; Alvear-Rodriguez 2000).

ROSP nesting success in Florida Bay depends on high prey concentrations that result from water levels at or below approximately 13 centimeters in dwarf mangrove habitats (Lorenz 2014). The results from this year reflect that ROSP nesting activity continued to be adversely influenced by the loss of optimal foraging conditions due to sea level rise. It is apparent from hydrological data that water levels at known ROSP foraging sites never fell below 13 centimeters during the 2018-2019 season (**Figure 6**). As a consequence, ephemeral shallows within the typical flight range of a foraging adult bird (12.4 km radius; Lorenz et al. 2002) remained inundated. Using Diamond Key as an example, ROSP began laying eggs around March 21 (**Table 7**), but water levels at historical foraging grounds were between 20 to 25 centimeters and did not recede until well after the mean hatch date of April 11 (**Figure 6**). Newly hatched chicks were observed in the nests on April 12, a few nests had failed by April 21, and by May 2, all nests had failed and half were occupied by Great Egrets (GREG).

Given the trends in water levels elsewhere in Florida Bay, ROSP nesting at colonies in the Southeast and Central regions did not fare much better. Mean hatch dates in mid-January limited foraging options for adults. The limited success in the Southeast region could reasonably be attributed to the proximity of Pigeon and Bottle keys to the remaining historical foraging grounds on Key Largo.

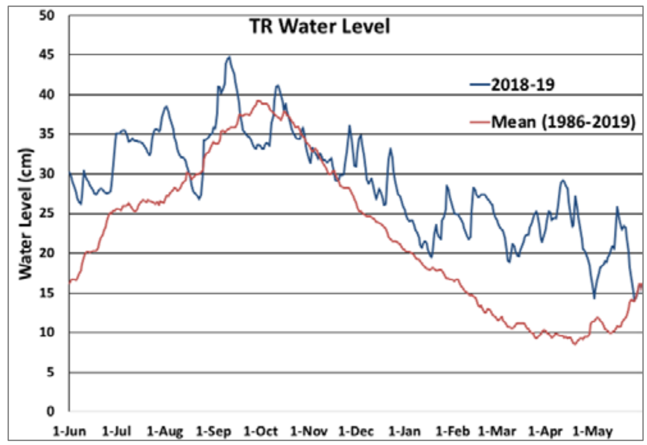

Figure 6. Daily water level from the TR hydrostation and the 34-year mean daily water level. This location historically was the primary foraging grounds for ROSP nesting in the Northeastern region of Florida Bay.

The greatest nesting success occurred in the Northwest region. Colonies at Sandy and Palm keys benefitted from the nearby foraging grounds of Snake Bight, Bear Lake, and Lake Ingraham, where water levels exhibited a more conducive drawdown pattern for foraging (**Figure 7**). Mean lay and hatch dates from this region were well timed to occur within the dry period, with the exception of Oyster Key, which may have initiated too early (mean hatch date December 2), just as a major reversal in the drying pattern was peaking (**Figure 7**). While the number of total observed nests at Paurotis Pond was remarkable, the low success rate suggests limited available foraging habitat; Bear Lake and Lake Ingraham are outside the typical adult foraging range. Two previously unrecorded instances of solitary nesting were observed in the Northwest region. One nest found near Slagle's Ditch, an area 7.5 miles north of Sandy Key on the mainland, had an unknown fate. A second nest was discovered on the south side of Bear Lake and was successful in rearing at least one chick to 21 days old. These observations may indicate that high water levels are acting as a stressor and driving birds to nest farther inland where water conditions are more subject to drawdowns. Both nests were found accidentally, and it is possible that additional pairs are nesting solitarily throughout Cape Sable. If so, attaining accurate counts will be difficult.

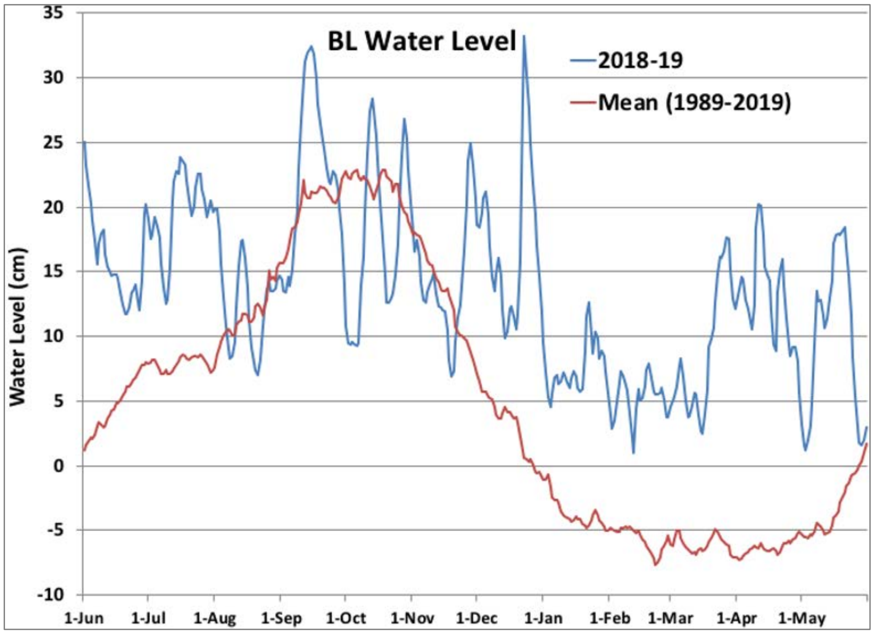

Figure 7. Daily water level from the BL hydrostation and the 31-year mean daily water level. This hydrostation is located in the primary foraging grounds for ROSP nesting in the Northwestern region of Florida Bay.

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NESTING ACTIVITY OF WATER BIRDS ON SPOONBILL COLONY KEYS IN FLORIDA BAY AND BAYWIDE AERIAL SURVEY RESULTS, 2019 SEASON

Audubon Florida and Everglades National Park performed surveys of nesting water birds in Florida Bay and adjacent habitats. The results of those surveys were combined by selecting the largest nest count for each species for each nesting site regardless of who performed the survey, the survey method, or the time of the survey. Results are presented in **Table 8**.

METHODS

Audubon Florida

While surveying known Roseate Spoonbill (ROSP) colonies throughout Florida Bay, 12 other species of water birds were observed nesting on the islands (**Figure 8**). Attempts were made to count the nests, but these findings should not be treated as a thorough or exhaustive survey of water birds in the bay. Many keys were not surveyed at all because ROSP did not nest on them. Also, areas beyond ROSP nesting sites on a given key were not searched.

That stated, every effort was made to thoroughly find all ROSP and Reddish Egret (REEG) nests. Total counts were used when possible, rather than the maximum count observed on a given survey. REEG recently have become a species of interest at the state and local level and are now being treated the same as ROSP (i.e., attempts are made to find all nests and document productivity). The REEG estimates likely are an accurate representation of effort for this species in Florida Bay.

Everglades National Park

Aerial surveys were conducted in Florida Bay on December 17, 18, and 19; February 12 and 19; March 18, 20, and 21; and April 17 using a National Park Service Cessna 206 high-wing float aircraft. Surveys could not be conducted in January due to the federal government shutdown. Peak nest counts for wading birds and Brown Pelicans (BRPE) were recorded by island or island group. Nesting Double-crested Cormorants (DCCO) were noted, but nest numbers were not estimated. The survey area included most islands and island groups within Florida Bay.

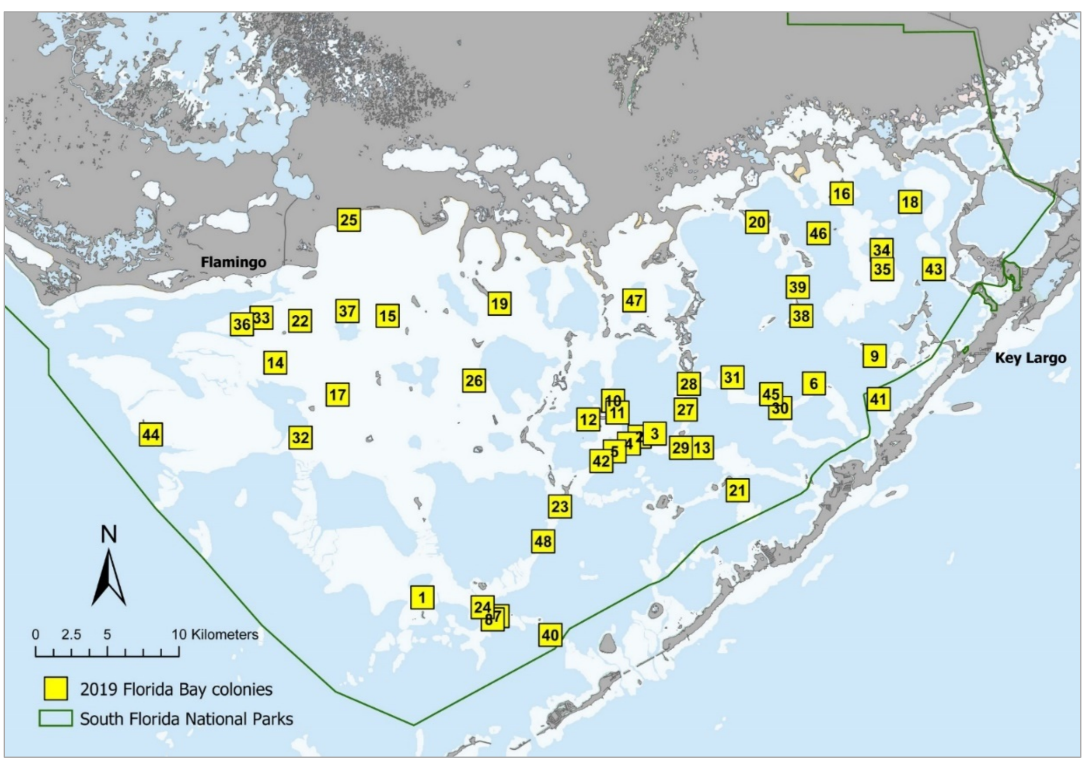

Figure 8. Active nesting colony sites in Florida Bay, 2019. **Table 8** contains the colony names and details.

Table 8. Peak nest numbers found in Florida Bay wading and water bird colonies through April 2019. Underlined numbers are estimates collected by Audubon Florida using ground surveys, while plain text numbers are estimates collected by Everglades National Park from aerial surveys.

Map ID	Colony	Latitude	Longitude	GBHE	GWHE	GREG	REEG	LBHE	SNEG	TRHE	ROSP	WHIB	BRPE	DCCO	Total
1	Arsenicker Keys, upper and lower	24.93180	-80.82707												**0**
2	Bob Allen Keys, central	25.03279	-80.67685												**0**
3	Bob Allen Keys, east	25.03469	-80.66637												**0**
4	Bob Allen Keys, west	25.02845	-80.68426												**0**
5	Bob Allen Keys, west, small	25.02353	-80.69413		2										**2**
6	Bottle Key	25.06602	-80.55628		2						1				**3**
7	Buchanan Keys, east	24.91996	-80.77522	1									7	2	**10**
8	Buchanan Keys, west	24.91791	-80.77857												**0**
9	Butternut Keys, middle	25.08322	-80.51419					2		250	9	40			**301**
10	Calusa Keys, big	25.05542	-80.69512		3		2				1				**1**
11	Calusa Keys, small island SE of Big Calusa	25.04801	-80.69211										18	9	**27**
12	Calusa Keys, west (Bruce Key)	25.04371	-80.71225								1				**1**
13	Captain Key	25.02583	-80.63380		10						8				**18**
14	Clive Key	25.07971	-80.92849												**0**
15	Cormorant Key	25.10915	-80.85087		7										**7**
16	Deer Key	25.18557	-80.53665												**0**
17	Dildo Key	25.05960	-80.88542	19	27										**46**
18	Duck Key	25.18011	-80.48931				6				8				**14**
19	Dump Keys, north and south	25.11678	-80.77342												**0**
20	Eagle Key	25.16779	-80.59527		9		1				1				**11**
21	East Key	24.99888	-80.60918		2									9	**11**
22	Frank Key	25.10609	-80.91138		3										**3**
23	Gopher Keys, north and south	24.98893	-80.73192												**0**
24	Green Mangrove Key	24.92559	-80.78548												**0**
25	HanVan, Gibby Point	25.16966	-80.87754												**0**
26	Jim Foot Key	25.06834	-80.79112												**0**
27	Jimmie Keys, central	25.04978	-80.64493		4		5			225	7				**241**
28	Jimmie Keys, north	25.06596	-80.64272		1		1				5				**7**
29	Jimmie Keys, south including First Mate	25.02575	-80.64832		2						6			9	**17**
30	Low Key	25.05064	-80.57963		2						4				**6**
31	Manatee Keys	25.06999	-80.61251		3										**3**
32	Man of War Key	25.03250	-80.91111	4	3								57	+	**64**
33	Murray Key	25.10806	-80.93806		2										**2**
34	Nest Keys, north	25.14988	-80.50914												**0**
35	Nest Keys, south	25.13783	-80.50871				1								**1**
36	Oyster Keys	25.10392	-80.95156		4						13		81		**98**
37	Palm Key	25.11226	-80.87861	8	4	4	5				82				**103**
38	Park Keys, south	25.10854	-80.56482										6		**6**
39	Park Keys, north	25.12677	-80.56724												**0**
40	Peterson Keys, south	24.90806	-80.73873	1	5										**6**
41	Pigeon Key	25.05600	-80.51150		6	2	2				10			42	**62**
42	Pollock Keys	25.01750	-80.70333		6										**6**
43	Porjoe Key	25.13777	-80.47305												**0**
44	Sandy Key	25.03451	-81.01448	2	12	15	2	+	+	120	23	40		100	**314**
45	Stake Key	25.05936	-80.58583		3	1	3				4				**11**
46	Tern Keys	25.16056	-80.55278				2			200		100			**302**
47	Triplet Key	25.11862	-80.68025		5	3									**8**
48	Twin Keys, south	24.96700	-80.74357		4						5				**9**
	Total			**35**	**131**	**25**	**30**	**2**	**0**	**795**	**188**	**180**	**169**	**171**	**1,726**

Note: BCNH and NECO were not observed (count = 0).
+ Present but not counted.

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COLONIAL NESTING BIRDS IN BISCAYNE NATIONAL PARK

Nesting colonies of wading birds and seabirds are important indicators of ecosystem health as they respond to changes in food abundance, food quality, contaminants, invasive species, and disturbances. The acts of selecting mates, building nests, laying eggs, and rearing chicks are energy intensive. If the habitat is insufficient to support these activities, nesting success will suffer and may indicate a problem in the ecosystem. The South Florida/Caribbean Inventory and Monitoring Network (SFCN) of the National Park Service is monitoring colonial nesting birds in Biscayne National Park, and this report summarizes the results for the July 2018 through June 2019 nesting year.

The specific objectives of this monitoring program are to determine status and long-term trends in:

- The number and locations of active colonies of colonial nesting birds with a special focus on Double-crested Cormorants (DCCO), Great Egrets (GREG), Great White Herons (GWHE), Great Blue Herons (GBHE), White Ibises (WHIB), and Roseate Spoonbills (ROSP) (referred to as focal species).
- The annual peak active nest counts of colonial nesting birds in Biscayne National Park for the focal species.
- Changes in an annual nesting index (sum of monthly nest counts) for the focal species.
- Changes in the timing of peak nest counts for the focal species.

METHODS

The monitoring process in 2018-2019 consisted of an annual park-wide survey via helicopter to locate new nesting colonies of wading birds and seabirds coupled with monthly surveys of colonies detected during the annual survey. Two SFCN staff, a photographer and an observer, participated in each survey. As the helicopter circled each island colony, the colonies were photographed, and the observer recorded the number of visible nesting and non-nesting birds. Approximately 450 photographs were taken during each survey. The photographs were downloaded for processing and analyzed to identify active nests by species. Nests were circled and counted from the processed photographs.

Peak nest counts were identified for each colony and summed across colonies to calculate the peak nesting year total across the park for each species. In addition, an annual nesting index was calculated, which is the sum of monthly nest counts for the entire nesting year. The nesting estimates for months with no sampling were calculated as the average of the months before and after the missing month. SFCN used the annual nesting index as well as peak nest counts because some species (e.g., DCCO) nest in all months and peak nest counts alone were considered insufficient to describe the nesting effort. Trying to estimate the true number of nest starts is not feasible at this time. This year's peak nest counts and nesting index were compared to the seven previous nesting years' mean, maximum, and minimum. Complete methods are described by Muxo et al. (2015).

Colony surveys were conducted from July to December 2018, in February 2019, and from April to June 2019. The January 2019 flight did not occur because of the federal government shutdown and the March 2019 flight did not occur because of helicopter availability. The nine colonies surveyed during the routine monthly flights were: Kings Road Island (25.49250, -80.33861), Mangrove Key (25.39444, -80.31583), West Arsenicker (25.40528, -80.31722), Arsenicker Key (25.39667, -80.28611), Jones Lagoon (25.37194, -80.24111), Ragged Key 4 (25.53040, -80.17234), Ragged Key 5 (25.52722, -80.18972), Soldier Key, (25.59027, -80.16139) and Kings Bay (25.6286, -80.30667) (**Figure 9**). Although the Kings Bay colony is located north of the park boundary, it is being monitored because of its proximity to the park. The birds nesting at Kings Bay most likely use the park for resources and provide a more complete a picture of colonial birds using Biscayne Bay.

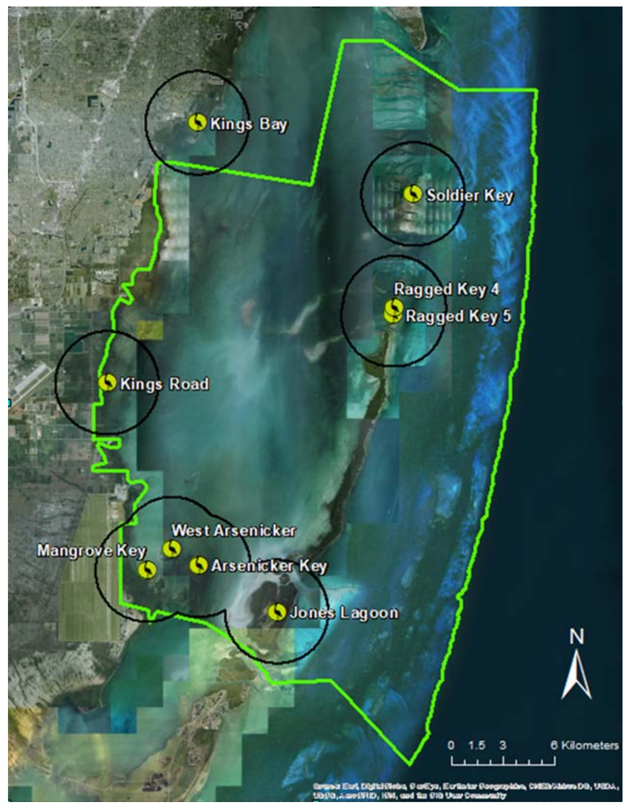

Figure 9. Nine island colonies monitored within Biscayne National Park and the estimated foraging areas.

RESULTS AND DISCUSSION

In the 2018-2019 nesting year, the SFCN completed its ninth year of monitoring colonial nesting birds in Biscayne National Park. This year's results include a new colony, Ragged Key 4, located approximately 25 meters north of Ragged Key 5 (**Figure 9**). When interpreting the data for this nesting season, it is important to consider January and March did not have surveys.

The monitoring results have yielded valuable nesting data for documenting species-specific nesting patterns and trends. Survey results are presented by grouping bird species according to their feeding method: diver, stalk and strike, and tactile. Species-specific information is presented with a focus on DCCO, GREG, GWHE, GBHE, WHIB, and ROSP. A breakdown of active nests for the focal species, including counts for nests with chicks and nests with eggs along with seasonal nesting periods, is shown in **Table 9**.

In the 2018-2019 nesting season, DCCO nested at every colony (**Figure 10**). The peak nest count for DCCO occurred in August 2018 with 735 nests, down 9% from previous years but within the previous data range of 792 to 1,336 nests (**Table 9**; **Figure 11**). The annual nesting index of 5,908.5 nests was slightly below average but within the previous range of 4,927 to 7,552.5 nests. DCCO continue to nest year-round and account for 91% of nests counted. Seven of the nine previously monitored colonies showed lower peak nest counts than the mean of previous years. King's Bay and West Arsenicker were the only colonies showing an increase.

GBHE were observed nesting at six of the nine colonies (**Figure 10**). The peak nest count for the 2018-2019 nesting season was 13 nests, compared to a mean of 11.9 nests in previous years, and within the previous data range of 6 to 15 nests (**Figure 12**). Jones Lagoon had the highest number of GBHE nests (6 nests).

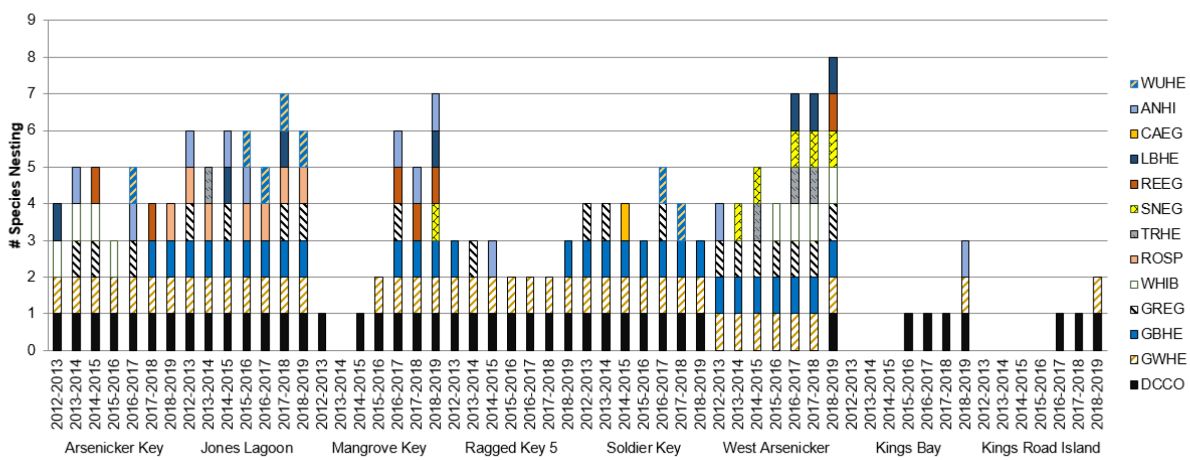

Figure 10. Number of species detected nesting, by colony and year. (Includes all egrets, ibises, spoonbills, and herons.)

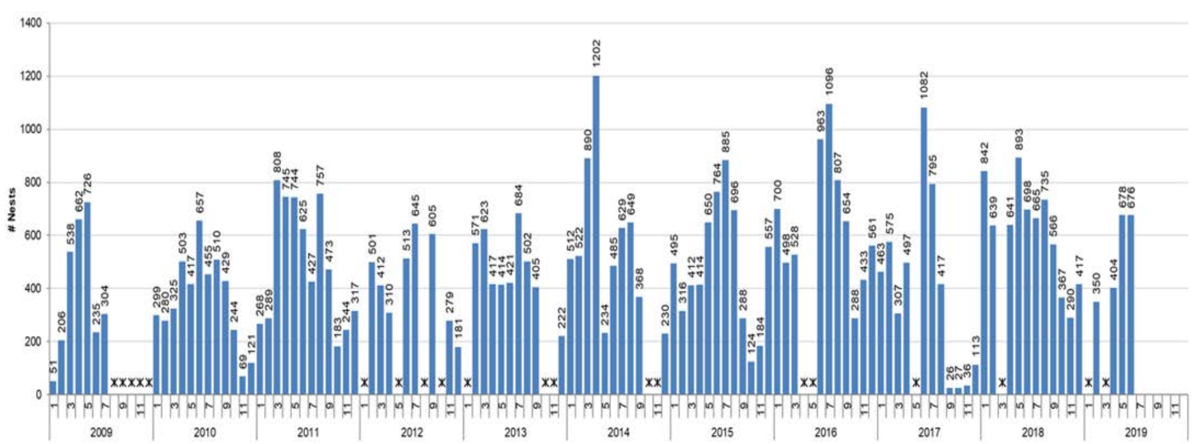

Figure 11. Number of DCCO nests per month. (*Months not sampled.)

Table 9. Peak nest and nesting index for Biscayne National Park, by species and colony, for the 2018-2019 nesting year, plus the mean, percent change, maximum, and minimum of the eight previous nesting years (July through June).

Species	Peak Nest					Nesting Index				
	2018-2019	Mean	% Change	Max.	Min.	2018-2019	Mean	% Change	Max.	Min.
Biscayne National Park										
DCCO	940	1,038.7	-9%	1,336	792	5,908.5	5,979.5	-1%	7,552.5	4,957.5
GBHE	13	11.9	9%	16	6	48.0	34.6	39%	48.5	12.0
GREG	4	16.1	-75%	29	4	4.0	47.0	-91%	84.5	4.0
GWHE	40	29.2	37%	46	18	181.0	118.7	53%	192.0	68.5
ROSP	3	5.0	-40%	12	0	7.0	11.7	-40%	25.0	0.0
WHIB	33	52.3	-37%	95	24	41.0	87.2	-53%	206.0	27.0
Arsenicker Key										
DCCO	56	146.7	-62%	257	56	298.5	677.7	-56%	983.5	298.5
GBHE	1	0.4	150%	2	0	1.0	0.8	20%	5.0	0.0
GREG	0	0.6	-100%	2	0	0.0	1.3	-100%	5.0	0.0
GWHE	4	5.4	-26%	13	2	16.0	22.2	-28%	54.5	11.5
ROSP	1	0.5	100%	1	0	1.5	0.8	100%	1.5	0.0
WHIB	0	31.5	-100%	60	0	0.0	41.6	-100%	87.0	0.0
Jones Lagoon										
DCCO	55	103.0	-47%	135	55	430.5	546.5	-21%	905.0	298.0
GBHE	6	6.2	-4%	10	2	29.5	21.3	38%	33.5	6.5
GREG	1	1.0	0%	2	0	1.0	1.0	0%	2.0	0.0
GWHE	10	9.2	8%	14	6	56.5	40.2	40%	64.0	23.0
ROSP	2	4.9	-59%	12	0	5.5	11.5	-52%	25.0	0.0
WHIB	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
Mangrove Key										
DCCO	16	31.3	-49%	115	0	67.0	102.1	-34%	309.0	0.0
GBHE	3	1.8	67%	4	0	10.0	4.4	130%	12.0	0.0
GREG	0	0.3	-100%	1	0	0.0	0.4	-100%	2.0	0.0
GWHE	8	1.9	324%	8	0	37.5	7.6	396%	37.5	0.0
ROSP	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
WHIB	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
Ragged Key 5										
DCCO	351	410.8	-15%	706	294	2,170.0	2,715.3	-20%	3,568.0	2,072.5
GBHE	1	0.4	133%	1	0	2.5	0.5	400%	2.5	0.0
GREG	0	0.2	-100%	1	0	0.0	0.2	-100%	1.0	0.0
GWHE	4	4.7	-14%	8	2	24.0	19.1	26%	36.5	10.0
ROSP	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
WHIB	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
Solider Key										
DCCO	171	206.7	-17%	342	140	1,286.0	1,283.8	0%	1,575.5	870.5
GBHE	1	1.1	-10%	2	1	3.5	2.9	19%	9.0	1.0
GREG	0	0.5	-100%	1	0	0.0	0.4	-100%	1.5	0.0
GWHE	5	4.2	18%	9	2	33.0	16.3	102%	36.5	5.0
ROSP	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
WHIB	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
West Arsenicker										
DCCO	2	1.4	38%	10	0	2.0	1.8	9%	13.0	0.0
GBHE	1	2.8	-64%	5	1	1.5	5.6	-73%	15.0	1.5
GREG	3	14.1	-79%	27	3	3.0	44.0	-93%	82.5	3.0
GWHE	5	3.2	55%	6	1	8.0	12.4	-36%	29.5	4.0
ROSP	0	0.0	N/A	0	0	0.0	0.0	N/A	0.0	0.0
WHIB	33	24.3	36%	95	0	41.0	45.7	-10%	206.0	0.0
Kings Bay										
DCCO	218	275	-21%	357	218	1,402.5	1,291.1	9%	1,739.5	424
GWHE	1	0.3	233%	1	0	1.5	0.4	300%	1.5	0.0
Kings Road Island										
DCCO	33	54	-39%	66	33	108.0	182.0	-41%	222.5	108.0
GWHE	1	1	0%	1	1	1.0	0.5	100%	1.0	0.0
Ragged Key 4										
DCCO	38	25	52%	38	12	144.0	80.0	80%	144.0	16.0
GWHE	3	1.5	100%	3	1	3.5	2.8	25%	3.5	2.0

Note: Kings Bay only has 4 years of data for comparison, Kings Road Island only has 3 years of data for comparison, and this is the first year data were collected at Ragged Key 4.

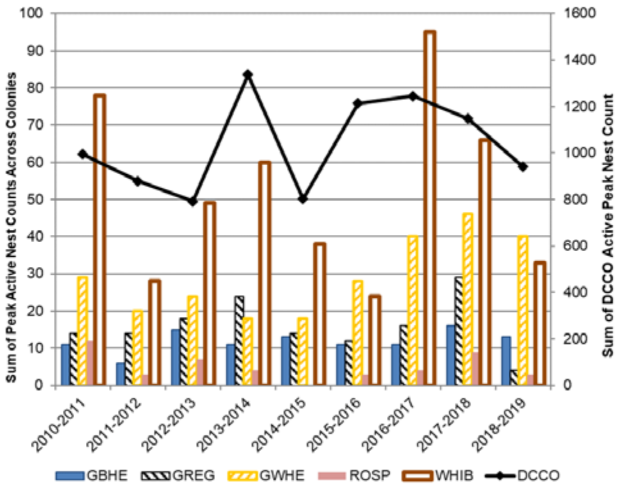

Figure 12. Total of peak active nest counts from all colonies.

The GWHE peak nest count of 40 nests is 37% above the mean (29.2 nests) of previously monitored seasons, but it is below the previous maximum peak nest count of 46 nests recorded during the 2010-2011 nesting season (**Table 9**). This is the first time we have recorded GWHE nesting on all nine colonies (**Figure 10**).

Jones Lagoon and Arsenicker Key were the only two colonies where ROSP were observed nesting. The peak nest count was 3 nests, which is a 40% below the previous year's mean of 5 nests but within the previous data range of 0 to 12 nests (**Table 9**).

The WHIB peak nest count of 33 nests was 37% below the mean of the previous 8 years of 52.3 nests (**Table 9**). This season's nest count was within the minimum and maximum range of 24 to 95 nests. This is the second year in a row with a lower peak nest count following the highest recorded number of 95 nests during the 2016-2017 nesting season (**Figure 12**).

West Arsenicker had the highest species richness of nesting birds with eight species observed (**Figure 10**). Mangrove Key was the next highest at seven species nesting. This past nesting season was the first time GWHE were observed at Kings Bay and Kings Road Island colonies. This year's report includes results from a new colony, Ragged Key 4. Ragged Key 4, along with Kings Bay and Kings Road Island, added 289 DCCO to the total number of nests.

Overall, the number of nests was slightly lower than the average of the past eight nesting years for four of the focal species. With the exception of GREG, peak nest counts and nesting indices fell within the previous range seen in those years (**Figure 13**).

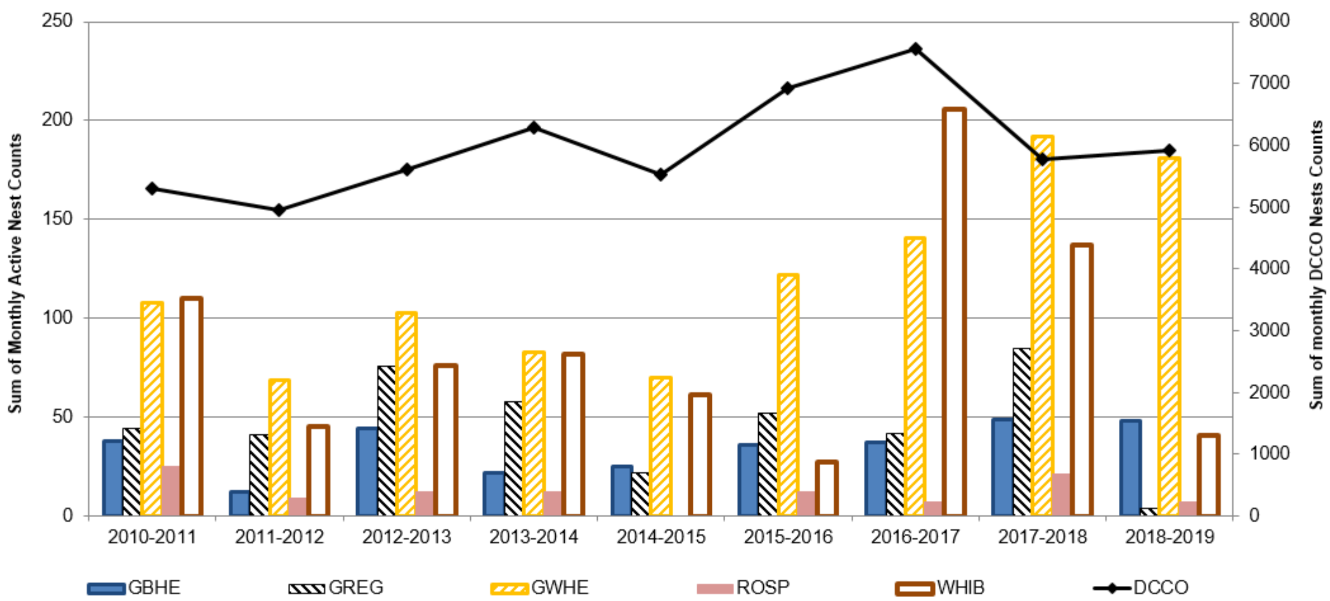

Figure 13. Annual nesting index across colonies, by focal species. The number of nests counted at each colony during each month was summed to create an annual nesting index across all colonies for the six focal species. This number exceeds the actual number of nest starts as a single nest could be counted during two or more monthly visits.

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SOUTHWEST FLORIDA

The 2019 nesting season represented the 62nd consecutive year monitoring the Wood Stork (WOST) colony at Corkscrew Swamp Sanctuary. In 2019, Audubon Florida monitored five wading bird colonies in Lee and Collier counties, each of which has been used as a WOST colony site within the previous decade. Unseasonable rainfall leading to a significant dry season reversal in January 2019 led to failed WOST nesting at two inland colonies and a delay in WOST nesting at a colony on the Caloosahatchee River. The historical Corkscrew WOST colony that averaged more than 3,300 nests per year in the 1960s (including 2 years with no nesting) and was once the largest WOST colony in North America, averaged 74 nests per year in the 2010s (with WOST only fledging chicks 3 of 10 years). In a region where wading bird populations are stressed by foraging habitat decline and loss due to development as well as a lowered dry season water table, failed or reduced nesting due to meteorological events as occurred in 2019 is particularly impactful. The ability of Southwest Florida wetlands to continue supporting WOST nesting depends on addressing wetland degradation and loss and protecting hydrologic function of remaining wetlands.

METHODS

Reported rainfall and water level data are recorded from a standard rain gauge and staff gauge located at Corkscrew Swamp Sanctuary and recorded daily since 1959 (Clem and Duever 2018). Monthly aerial surveys from a fixed-wing aircraft were conducted December 2018 to June 2019. At each colony location, a digital SLR camera with a 70-300 mm lens was used to take a series of overlapping photographs of the colony at an altitude of 500 to 1,000 feet. For each colony, peak nest counts are reported from the monthly survey with the highest number of nests but few to no branchlings. Reported peak nest counts are conservative as new nests were observed throughout the season.

HYDROLOGY

Monthly rainfall and daily water levels from June through mid-December 2018 were near average. A rainfall event on December 21, 2018 caused water levels to rise approximately 1.5 inches, and water levels returned to pre-recession levels in about 2 weeks. A series of rainfall events from January 20 through February 27 caused water levels to rise nearly 8 inches through February, peaking around March 1, after which water levels receded fairly consistently until summer rains began in early June (**Figure 14**).

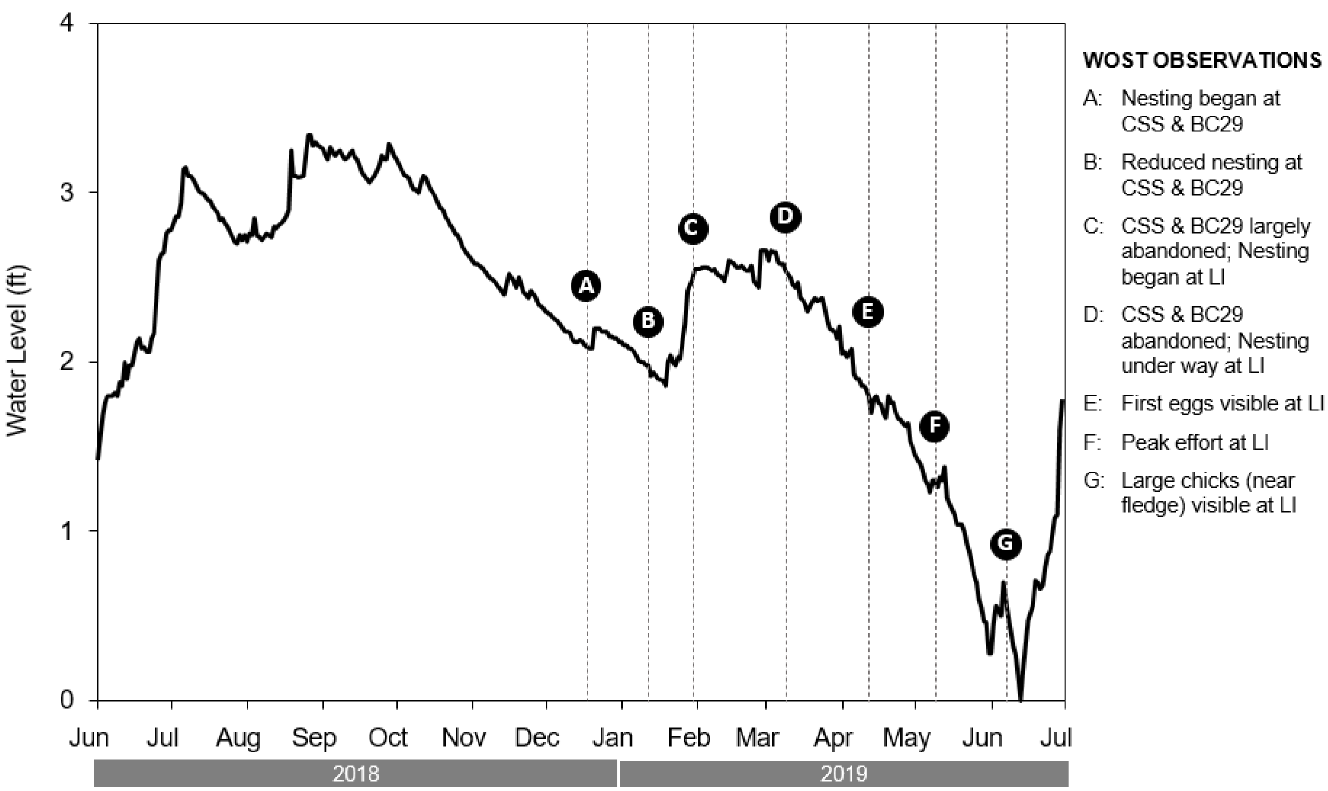

Figure 14. Daily water level (in feet) at Corkscrew Swamp Sanctuary's "B" staff gauge, June 2018 through June 2019 (zero represents ground level at the gauge). Dashed vertical lines indicate dates of WOST nest monitoring flights, and letters (A-F) summarize primary flight observations.

NEST SURVEYS

WOST began nesting in early December at inland colonies (Corkscrew Swamp Sanctuary and Baron Collier 29). These colonies failed, however, following the January-February dry season reversal event. On the Caloosahatchee River, WOST initiated nesting in late January to early February, but the first chicks and peak nesting effort were not seen until early May, suggesting the earliest nest starts were unsuccessful. A total of 207 WOST nests were observed by Audubon Florida staff in Southwest Florida in 2019 (**Table 10**).

Table 10. Peak numbers of nests, month of peak effort, and whether chicks fledged for WOST colonies in Southwest Florida in 2019.

Colony	Number of WOST Nests	Month of Peak Effort	Chicks Fledged?
Corkscrew Swamp Sanctuary	17	December	No
Baron Collier 29	26	December	No
Collier Hendry Line	0	--	No
Lenore Island	164	May	Yes
Caloosahatchee East	0	--	No
Total	**207**	--	--

Corkscrew Swamp Sanctuary (26.377196°, -81.615280°)

WOST nesting initiated at the Corkscrew Swamp Sanctuary colony in early December, with 17 WOST observed sitting on nests during the first monitoring flight of the season (December 18). During the following flight on January 10, a notably smaller number of WOST were observed in the colony, but most were not associated with nests. By March 7, no WOST were observed in the colony. No WOST or other nesting wading birds were seen by Audubon Florida staff in the Corkscrew Swamp Sanctuary colony in April, May, or June. However, Florida Fish and Wildlife Conservation Commission staff observed two WOST chicks fledged from this colony (Kathleen Smith, pers. comm.). The failure of the Corkscrew Swamp Sanctuary colony was concurrent with the January-February dry season reversal event that caused water levels to rise to the point of re-inundating wet prairies, dispersing aquatic prey and reducing prey densities throughout the region.

Barron Collier 29 (26.273025°, -81.344057°)

WOST nesting initiated at the Barron Collier 29 colony in early December, with 26 WOST observed sitting prone on nests on December 18. Nesting effort declined in February and March, and all WOST were gone from the Barron Collier 29 colony by March 7. No WOST were observed in this colony for the remainder of the nesting season. By early May, Great Egret (GREG) and Cattle Egret (CAEG) nesting initiated in the colony, but the success of those nests is unknown. As seen in the Corkscrew Swamp Sanctuary colony, the timing of the failure of WOST at Barron Collier 29 in 2019 was concurrent with the significant January-February dry season reversal event.

Collier-Hendry Line (26.370383°, -81.272717°)

No wading bird nesting activity was observed at the Collier-Hendry Line colony in 2019.

Caloosahatchee East (26.696583°, -81.794950°)

No WOST nesting was observed at the Caloosahatchee East colony in 2019. GREG and Great Blue Heron (GBHE) nesting was observed beginning in early March, although it is unknown whether chicks were fledged.

Lenore Island (26.688867°, -81.830150°)

WOST nesting initiated at the Lenore Island colony in mid-January, with a small number of WOST observed sitting prone on nests on January 31. While WOST were observed sitting on nests in March and April, the first chicks were observed in the colony in early May. Peak nesting activity was observed May 7, with 164 WOST nests. While numerous WOST branchlings were observed in the Lenore Island colony in early June, the fate of these chicks is unknown given wet season water levels began to rise in mid-June. In addition to WOST, this colony also supported GREG, GBHE, CAEG, and Brown Pelican (BRPE) nesting in 2019.

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HOLEY LAND AND ROTENBERGER WILDLIFE MANAGEMENT AREAS

Holey Land Wildlife Management Area supported three small wading bird nesting colonies this breeding season. Two colonies returned to their previous nesting locations along the eastern boundary of Holey Land (26.364223, -80.685081; 26.392029, -80.687988). Each colony contained approximately 20 Tricolored Heron (TRHE) and 15 Little Blue Heron (LBHE) nests. A new colony of approximately 15 Anhinga (ANHI) nests was found in the northeastern corner of Holey Land (26.42809, -80.69825).

No nesting colonies were observed in Rotenberger Wildlife Management Area this year.

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CHARLOTTE HARBOR AQUATIC PRESERVES AND J.N. "DING" DARLING NATIONAL WILDLIFE REFUGE COLONIAL WADING AND DIVING BIRD NEST MONITORING

INTRODUCTION

For 12 consecutive years, the Florida Department of Environmental Protection (FDEP) and U.S. Fish and Wildlife Service have collaborated to collect wading and diving bird nesting data. Staff at Charlotte Harbor Aquatic Preserves (CHAP), a field site of FDEP's Office of Resilience and Coastal Protection, and J.N. "Ding" Darling National Wildlife Refuge (NWR) have conducted colonial nesting bird surveys within the Ding Darling NWR Complex, and the Matlacha Pass, Pine Island Sound, Gasparilla Sound-Charlotte Harbor, Cape Haze, and Lemon Bay Aquatic Preserves (**Figure 15**). Colonial wading and diving bird nest monitoring began in 2008 with 9 islands and expanded to 34 islands in 2011. This year, 37 islands were monitored, and 26 were identified as active wading and diving bird nesting sites. Goals of this continuous study include establishing a long-term data set to assess nesting effort and seasonality and to monitor the activity status of known rookeries and establishment of new rookeries in the greater Charlotte Harbor area. In 2017, two islands in Pine Island Sound (Hemp Key and Broken Islands) were designated by the Florida Fish and Wildlife Conservation Commission as Critical Wildlife Areas. The islands were posted as such in 2018.

METHODS

The study area was divided between the two agencies based on location. J.N. "Ding" Darling staff monitored islands in South Matlacha Pass, San Carlos Bay, and South Pine Island Sound. FDEP/CHAP staff monitored islands in North Matlacha Pass, North Pine Island Sound, Gasparilla Sound, Lemon Bay, and Cape Haze. Both agencies employed the same direct count method, with a boat captain, data recorder, and two observers. Islands were circled by boat, and nests were recorded by nesting stage (incubating, chicks, or unknown) for each species. The incubating stage was used when an adult was sitting on and shading the nest. The chicks stage was used when juvenile birds were visible in or near the nest. This category was counted as a nesting stage (chicks in the nest) and not used as a measure of productivity. The unknown stage was used when nesting stage could not be determined. Data were collected from February through July 2019. Peak numbers reflect the highest number of nests per species throughout the survey period. The total number of peak nests also were calculated for each island.

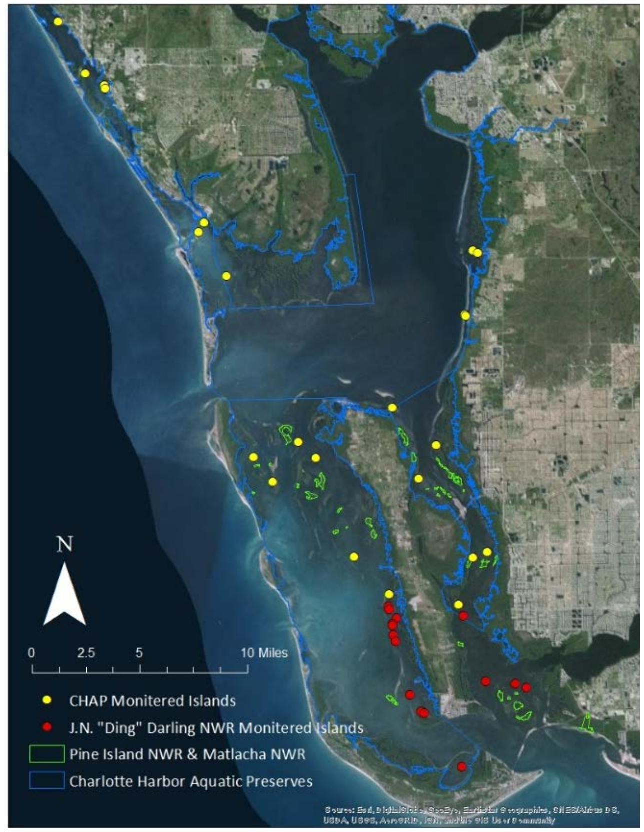


Figure 15. Locations of monitored bird colonies in CHAP and the J.N. "Ding" Darling NWR Complex.

RESULTS

The peak estimate for all colonial nesting birds in the study area was 1,693 nests (**Table 11**). This was an 8.3% increase from the 2018 total peak nesting effort. Diving birds constituted approximately 76% of the documented nests, while the remaining 24% were wading bird nests. The largest nesting efforts in 2019 occurred on Broken Islands (334 nests), Hemp Key (332 nests), and Useppa Oyster Bar (151 nests). Broken Islands also supported the greatest species diversity, with 10 species nesting in 2019. The 2019 total peak nesting effort marked the highest peak nesting effort in 6 years (**Figure 16**).

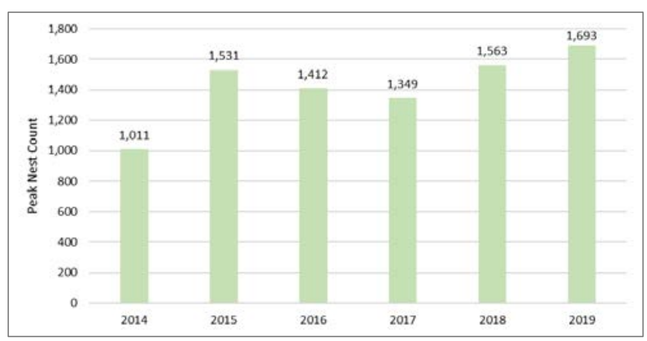


Figure 16. Annual peak nest counts in the study area from 2014 to 2019.

Table 11. Colonial nesting bird peak counts for CHAP and the J.N. "Ding" Darling NWR Complex, February through July 2019.

Colony (Island)	Lat.	Long.	GBHE	TRHE	LBHE	SNEG	GREG	REEG	CAEG	YCNH	BCNH	GRHE	WHIB	BRPE	DCCO	ANHI	ROSP	Total
Bodifer Key	26.4977	-82.1125	1															**1**
Broken Islands	26.6777	-82.1940	2	16	4	3		5			1		42	155	102	4		**334**
Burnt Store Marina N	26.7625	-82.0669	4	4	5	6	3		1						7			**30**
Burnt Store Marina S	26.7611	-82.0660	2							5	1	2						**10**
Clam Key	26.5063	-82.1128	1				1	2						9	15	4		**32**
E of Chadwick Cove	26.9289	-82.3511	10	1	1	10	15								5			**42**
Fish Hut Island	26.5467	-82.1245	1	5	1	1	1	1	2						8	1		**21**
Gasparilla Marina S	26.8269	-82.2625	3	1			13				2	1		51	33	5	1	**110**
Hemp Key	26.5999	-82.1532	9	1			13	2			1			146	160			**332**
N of Mason Island	26.5666	-82.0749	1															**1**
N of York Island	26.4945	-82.1043	1	1			5							71	14	3		**95**
N of Big Smokehouse	26.0000	-82.1225	1									2			10			**13**
NE of York Island	26.4940	-82.1021	1	3	1									29		1		**35**
NW of Mason Island	26.5543	-82.1251													5	2		**7**
NW of Pumpkin Key	26.5660	-82.1279	1												3	1		**5**
Oyster Creek W	26.8181	-82.3359	6				2							21	17		4	**50**
Pirate Harbor N	26.8052	-82.0597	9	3		3	16		12					68	31	4		**146**
Pirate Harbor SE	26.8037	-82.0565	2	14		2	1		23		1			21	32	2		**98**
Royal Palm Marina W	26.9640	-82.3708	11															**11**
Skimmer Island	26.5104	-82.0250	1	2	2	2	1						5	8	15	2		**38**
SW of Mason Island	26.5534	-82.1250		2											5	1		**8**
SW of Pumpkin Key	26.5640	-82.1275	1	1			1								18			**21**
Tarpon Bay Keys	26.4577	-82.0744	3	5		4	7	1			1			19	12	1		**53**
Upper Bird Island	26.5592	-82.0714	1															**1**
Useppa Oyster Bar	26.6513	-82.2134	2								1			82	66			**151**
White Pelican Island	26.7905	-82.2463	6		1	20	4	3		1	4				9			**48**
Total			**80**	**59**	**15**	**51**	**83**	**14**	**38**	**6**	**12**	**5**	**47**	**680**	**567**	**31**	**5**	**1,693**

Note: Nesting birds were not observed at the following colonies (islands): Bird Keys, Bird Rookery Keys, Cork Island, Crescent Island, Darling Keys, Givney Key, Little Oyster Creek, Lumpkin Island, Lower Bird Island, Masters Landing, and N Regla.

Species Summaries – Diving Birds

Double-crested Cormorant (DCCO)

DCCO nesting peaked at 567 nests, which is approximately 33% of the total nests in the 2019 season. This was a slight increase from 557 peak nests documented in 2018. Nesting was documented on 20 islands, with the highest nest count (160 nests) occurring on Hemp Key in May.

Brown Pelican (BRPE)

BRPE nesting peaked at 680 nests on 12 islands and accounted for approximately 40% of the nesting effort documented this season. The BRPE peak nest count was the highest in the 11-year study period. The highest nest count (155 nests) occurred at Broken Islands in April.

Anhinga (ANHI)

ANHI nesting peaked at 31 nests, which was down slightly from the 2018 peak count of 34 nests. The highest nest count (5 nests) occurred at Gasparilla Marina South in July.

Species Summaries – Wading Birds

Great Blue Heron (GBHE)

GBHE nesting efforts were documented on 24 of the 26 active islands. The peak nest count for GBHE was 80 nests. This was a 22% decrease from last year's peak nesting effort of 103 nests. Royal Palm Marina West had the largest number of nests (11 nests).

Tricolored Heron (TRHE)

TRHE nests were documented on 14 islands, with a peak nest count of 59 nests. This was slightly higher than last year's peak nest count of 55 nests. The highest nesting effort (16 nests) occurred at Broken Islands.

Little Blue Heron (LBHE)

LBHE nesting peaked at 15 nests in 2019. Nests were documented on seven islands, with the highest nest count (5 nests) at Burnt Store Marina North.

Snowy Egret (SNEG)

SNEG nesting occurred on 9 islands, with a peak nest count of 51 nests. This was a 25% decrease from the 2018 nesting effort of 68 nests. The highest nest count (20 nests) was recorded at White Pelican Island in June.

Great Egret (GREG)

GREG nesting peaked at 83 nests. This was only slightly lower than the peak nest count of 89 nests in 2018. The greatest GREG nesting effort (16 nests) was documented at Pirate Harbor North.

Reddish Egret (REEG)

REEG were documented nesting on six islands, with a peak nest count of 14 nests. This was an increase of 3 nests from 2018 peak nesting effort. The highest peak nest count of five occurred on Broken Islands in July.

Yellow-crowned Night Heron (YCNH)

Six nests were recorded in 2019, a slight decrease from the peak count of seven in 2018. Five nests were observed at Burnt Store Marina South in June.

Black-crowned Night Heron (BCNH)

BCNH nesting was documented on 8 islands and peaked at 12 nests. This was a decrease of 29% from the peak nest count (17 nests) in 2018. The highest nest count (4 nests) occurred at White Pelican Island in June.

Green Heron (GRHE)

GRHE nesting peaked at five nests, and nesting activity occurred on three islands. This was a 55% decrease from the peak nest count (11 nests) in 2018.

White Ibis (WHIB)

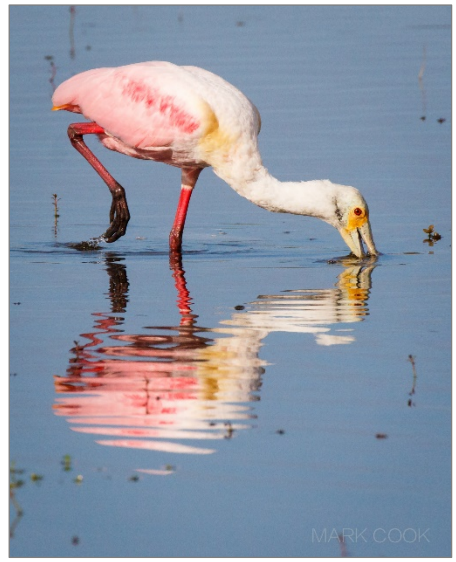
WHIB nesting occurred on 2 islands, with a peak count of 47 nests. This was approximately a 15% increase from last year's peak nest count of 41 nests. The highest nest count (42 nests) occurred at Broken Islands.

Cattle Egret (CAEG)

CAEG nesting peaked at 38 nests in 2018 and 2019. The highest nest count (23 nests) was at Pirate Harbor SE in July.

Roseate Spoonbill (ROSP)

Five ROSP nests were documented this season. Four of the nests were at Oyster Creek West, while the remaining nest was observed at Gasparilla Marina South. This was the second consecutive year that ROSP have been documented nesting in the study area. ROSP were first recorded nesting in 2018, with three nests.



CONCLUSIONS

The total peak nesting effort in 2019 was 1,693 nests, an increase of 8.3% from the 2018 total of 1,563 nests and the highest peak nesting effort since 2013. BRPE, DCCO, TRHE, WHIB, ROSP, and REEG experienced an increase in nesting effort in 2019. Conversely, ANHI, GBHE, SNEG, GREG, YCNH, BCNH, and GRHE experienced a decrease in nesting effort. The islands supporting the three largest nesting efforts in 2019 were Broken Islands (334 nests), Hemp Key (332 nests), and Useppa Oyster Bar (151 nests). These three islands supported 48% (817 of 1,693 nests) of the nesting effort in 2019. This is an increase from 2018 when the top three islands supported 41% (651 of 1,563 nests) of nesting effort.

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ESTERO BAY AQUATIC PRESERVE COLONIAL NESTING WADING AND DIVING BIRD MONITORING AND PROTECTION PROGRAM

Estero Bay Aquatic Preserve (EBAP) was designated in 1966, becoming Florida's first aquatic preserve. EBAP is a field site of the Florida Department of Environmental Protection managed by the Florida Coastal Office. The colonial nesting, wading, and diving bird monitoring and protection program began in 2008 at 15 islands and has expanded to 34 islands, 20 of which are active nesting sites. Two islands (Emily's Keys and Taylor Island) were added when they were discovered during the 2019 breeding season.

Historically, the highest concentration of wading and diving bird nesting activity has been observed on three islands: Matanzas Pass, Coconut Point East, and Big Carlos Pass West of 52. These islands are now designated as Critical Wildlife Areas (CWAs) and were marked in February 2018.

The objectives of this program are as follows:

- Provide peak estimates of nesting effort for each species of colonial nesting bird;
- Monitor population trends;
- Record movement of colonies, human disturbance, and bird fatalities due to fishing line entanglement;
- Reduce the number of entanglements and fatalities due to fishing line and trash within Estero Bay; and
- Provide recommendations for the management of nesting wading and diving bird colonies in the EBAP.

METHODS

Between 2008 and 2019, surveys were conducted monthly throughout the nesting season. Since 2012, surveys have been conducted year-round due to the extended period of nesting. Employing a direct count method, two observers surveyed each island by boat from a distance of 30 to 45 meters, with a third person recording the data for each nest's species and stage (Audubon Florida 2004). The primary observer (an EBAP staff member) was consistent between 2008 and 2016 but transitioned to another staff member in September 2016. In January 2019, the primary observer transitioned to another EBAP staff member. Trained volunteers and EBAP staff members conducted secondary observer counts. The average of the two observers' counts were reported. Peak nest counts from 2019 were compared with mean peak nest counts from 2008 through 2018, which represent an 11-year average for nesting effort in the EBAP. Peak nest counts of species that started nesting in recent years—Anhinga (ANHI), White Ibis (WHIB), and Roseate Spoonbill (ROSP)—were compared to average counts since their nesting establishment in EBAP.

RESULTS

The peak nesting effort for wading and diving birds was 531 nests (**Table 12**). June marked the height of the nesting season in the EBAP, with an estimated 388 active nests. The Matanzas Pass colony, with an annual peak of 189 nests, supported the greatest nesting concentration in the bay. Overall, nesting effort increased 21% from the 11-year average (**Table 13**). All species-specific increases or decreases in nesting effort are in comparison with the 11-year average.

Double-crested Cormorant (DCCO) nests were documented on seven islands. Nesting activity peaked in May (n = 37). DCCO peak nesting numbers for 2019 (n = 46) decreased 35%.

Brown Pelican (BRPE) nests were documented on three islands. Nesting activity peaked in May (n = 216), with a season peak of 227 active nests, a 94% increase.

Great Blue Heron (GBHE) nests were documented on 14 islands. Nesting effort peaked in March (n = 28), with a season peak of 44 nests, a 36% decrease. No white morphs were documented in 2019.

Great Egret (GREG) nests were documented on five islands. Nesting peaked in June (n = 25), and the annual peak was 45 nests, a 20% decrease in nesting effort.

Snowy Egret (SNEG) nests were documented on five islands, with peak nest counts in June (n = 35). SNEG had an annual peak nest count of 33 nests, a 15% increase.

Little Blue Heron (LBHE) nests were documented on five islands, with peak nest counts in May (n = 5). The annual peak nest count (n = 9) represented a 38% decrease in nesting effort.

Tricolored Heron (TRHE) nests were documented on five islands. Peak nesting effort occurred in June (n = 43). The annual peak (n = 57) represented a 69% increase in nesting effort.

Table 12. Peak nest counts documented in Estero Bay Aquatic Preserve colonies, January through August 2019.

Colony	Latitude	Longitude	DCCO	ANHI	BRPE	GBHE	GREG	SNEG	LBHE	TRHE	REEG	BCNH	YCNH	GRHE	ROSP	Total
Big Bird Island	26.38286	-81.84995	2			2						1				**5**
Big Carlos Pass between M-50 and M-52	26.43155	-81.90066	4			4						1	5			**14**
Big Carlos Pass M-43	26.42771	-81.90050											2			**2**
Big Carlos Pass between M-46 and M-48	26.42926	-81.90137												1		**1**
Big Carlos Pass W of M-52	26.42469	-81.89359	3		58		20	7	1	17	2	4				**112**
Big Hickory E of M-85	26.35315	-81.84164	5			5					2	1				**13**
Coconut Point East	26.38411	-81.84905	16	1	69	1	9	7	2	2		4			2	**113**
Coconut Point West	26.38111	-81.84976				2										**2**
Chain of Islands	26.43803	-81.86937												6		**6**
Denegre Key	26.43772	-81.86728	2			3		1		7	1	5		1		**20**
Estero River North	26.43653	-81.86091				1							7	2		**10**
Hurricane Pass/Rebecca's Island	26.46812	-81.95352				1										**1**
Matanzas Pass	26.46092	-81.95717	14		100	13	5	13	5	28	8	2	1			**189**
Kelsey's Island	26.40498	-81.86449				1										**1**
North Coconut M-2	26.40572	-81.86338				2										**2**
North Coconut E of M-3	26.41131	-81.85486				2	7	5	1	3	1	2	1			**22**
North Coconut M-4, Monkey Joe Key	26.40737	-81.85998				6	4									**10**
Taryn's Key	26.41069	-81.85412				1										**1**
Emily's Keys*	26.45286	-81.86753												2		**2**
Taylor Island**	26.42438	-81.89769										1	1	3		**5**
Total			**46**	**1**	**227**	**44**	**45**	**33**	**9**	**57**	**14**	**21**	**17**	**15**	**2**	**531**

N/A = not available.
* Surveys conducted between April and August.
** Surveys conducted between May and August.
Note: Nests were not observed (count = 0) in the following colonies: 619038c, Big Carlos Pass M-48, Big Carlos Pass S of M-48, Big Carlos Pass W of M-46, Big Hickory M-83 Seagrass Island, Big Hickory Pass M-49 2NW, Big Hickory Pass M-49 3NW, Estero River M-30, Estero River South, Hogue Channel M-78, Little Davis Key, New Pass M-21, New Pass M-9, and Ruth's Island.
Note: CAEG and WHIB were not observed (count = 0).

Table 13. Mean peak nest count (2008 to 2018), standard error, current (2019) peak nest count, and percent mean difference by species.

Species	Mean (2008-2018)	Standard Error	Standard Deviation	Peak (2019)	Percent Change	Percent Change 2018-2019
DCCO	70	5	17.6481	46	-35	-35
ANHI*	2	5	15.1041	1	-50	450
BRPE	117	4	13.6587	227	94	94
GBHE	69	4	14.3118	44	-36	-36
GREG	56	4	14.8796	45	-20	-55
SNEG	29	7	24.3235	33	15	15
LBHE	14	9	29.9452	9	-38	-38
TRHE	34	10	33.7202	57	69	69
REEG	7	11	35.3112	14	93	93
CAEG	1	11	35.2306	0	-100	-100
BCNH	16	11	35.1923	21	34	34
YCNH	19	7	24.0304	17	-11	-11
GRHE	6	4	13.4619	15	162	162
ROSP**	1	1	2.67324	2	100	1,000
WHIB*	2	1	2.81416	0	-100	-100
Total	**439**	**1**	**2.87649**	**531**	**21**	**21**

*ANHI and WHIB data were compared to 2018 data, not against the 11-year average.
**ROSP data were compared to 2017 and 2018 data, not against the 11-year average.

Reddish Egret (REEG) nests were documented on five islands, with peak nesting effort in June (n = 11). The annual peak nest count (n = 14) represented a 93% increase.

Black-crowned Night Heron (BCNH) nests were documented on nine islands, with peak nesting effort in August (n = 16). The annual peak (n = 21) represented a 34% increase.

Yellow-crowned Night Heron (YCNH) nesting were documented on six islands, with a peak in June (n = 15). The annual peak nest count was 17 nests, an 11% decrease in nesting effort.

Green Heron (GRHE) nests were documented on six islands, with peak nesting effort in July (n = 9). The annual peak nest count (n = 15) represented a 162% increase.

Cattle Egret (CAEG) nesting was not documented in Estero Bay in 2019.

ROSP nesting was documented on one island in May and June (n = 2). The annual peak nest count (n = 2) represented a 100% increase. This is the third recorded ROSP nesting effort in Estero Bay.

ANHI nesting was documented on one island in July, with a peak nesting effort of one nest. This is the second recorded ANHI nesting effort in Estero Bay.

WHIB nesting was not documented in Estero Bay in 2019. Since monitoring began, only two WHIB nests were documented in Estero Bay in 2018.

Between January and September 2019, volunteers contributed 365 hours of service to monitoring and protecting wading and diving bird colonies in Estero Bay. Staff and volunteers removed 1,172 feet of fishing line and 61 hooks from nesting islands and nearby locations during this time. Large-scale cleanups of the islands were conducted after the nesting season to minimize disturbance to colonies. Fourteen bird fatalities (5 DCCO, 4 BRPE, 1 SNEG, 1 ANHI, 1 ROSP, 1 Fish Crow [FICR], and 1 unknown) due to fishing line entanglement were documented.

Discussion

EBAP nesting activity exhibits annual variation. Despite the remaining hurricane damage, the annual peak nest count this season (n = 531) was greater than the 11-year average (n = 439) and the third highest season since monitoring began in 2008 (**Figure 17**).

Six species (BRPE, SNEG, TRHE, REEG, BCNH, and GRHE) showed improvement in nesting activity in 2019 compared to the 11-year average. For the third time on record, ROSP nested in Estero Bay. Five species (DCCO, GBHE, GREG, LBHE, CAEG, and YCNH) showed a decline in nesting activity in 2019 compared to the 11-year average. Two species (WHIB and ANHI) also saw a decline in nesting effort; however, they were first observed nesting in Estero Bay in 2018 and, therefore, were only compared to 2018 data.

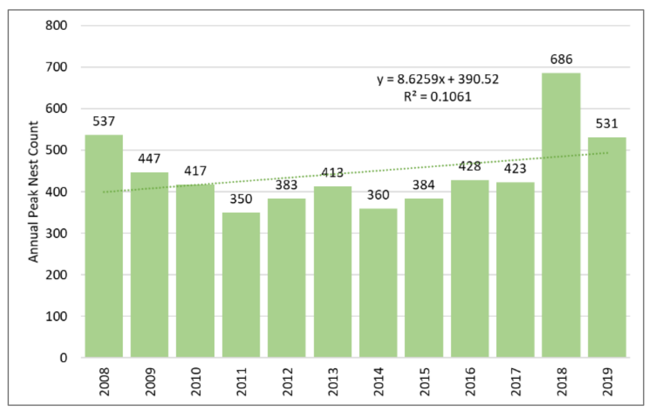

Figure 17. Annual peak nest counts in Estero Bay Aquatic Preserve from 2008 to 2019.

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CORKSCREW REGIONAL ECOSYSTEM WATERSHED MANAGEMENT AREA

In 2019, the Florida Fish and Wildlife Conservation Commission (FWC) monitored six wading bird nesting colonies in and around the Corkscrew Regional Ecosystem Watershed (CREW) Management Area and National Audubon Society's Corkscrew Swamp Sanctuary in Lee and Collier counties. Foraging and roosting aggregations were identified, with the goal of monitoring long-term trends in activity.

METHODS

Monthly systematic aerial surveys of CREW, Corkscrew Swamp Sanctuary, approximately half of the Larry Kiker Preserve, and Hidden Cypress Preserve covering 200 km² (49,389 acres) were conducted in a Robinson R66 helicopter from January through June 2019. Transects spaced 1.48 km (0.8 nautical miles) apart and oriented northeast to southwest (**Figure 18**) were flown at an altitude of 244 meters (800 feet). Once a colony was located, flight altitude was reduced to 152 meters (500 feet), GPS coordinates were recorded, and digital photographs were taken using a Canon EOS 7D with a 70-300 mm lens with image stabilization. Photographs were used to count nests and identify nesting species. Each photo was digitally marked using Adobe® Photoshop Elements 15 to avoid double-counting. Peak nest numbers (the highest nest count for the season) were reported within each colony.

HYDROLOGY

Monthly rainfall and daily water levels from June through mid-December 2018 were near average. A rainfall event on December 21, 2018, caused water levels to rise approximately 1.5 inches, and water levels returned to pre-recession levels in about 2 weeks. A series of rainfall events from January 20 through February 27 caused water levels to rise nearly 8 inches, peaking around March 1, after which water levels receded fairly consistently until summer rains began in early June.

RESULTS AND DISCUSSION

Six nesting colonies were monitored, including two Wood Stork (WOST) subcolonies (**Table 14**; **Figure 18**). The combined peak nesting number of 346 nests was a 63% decrease from 2018. Overall, there was a declining trend in peak counts for two (Orange Groves and Cypress East) of the three consistently monitored colonies.

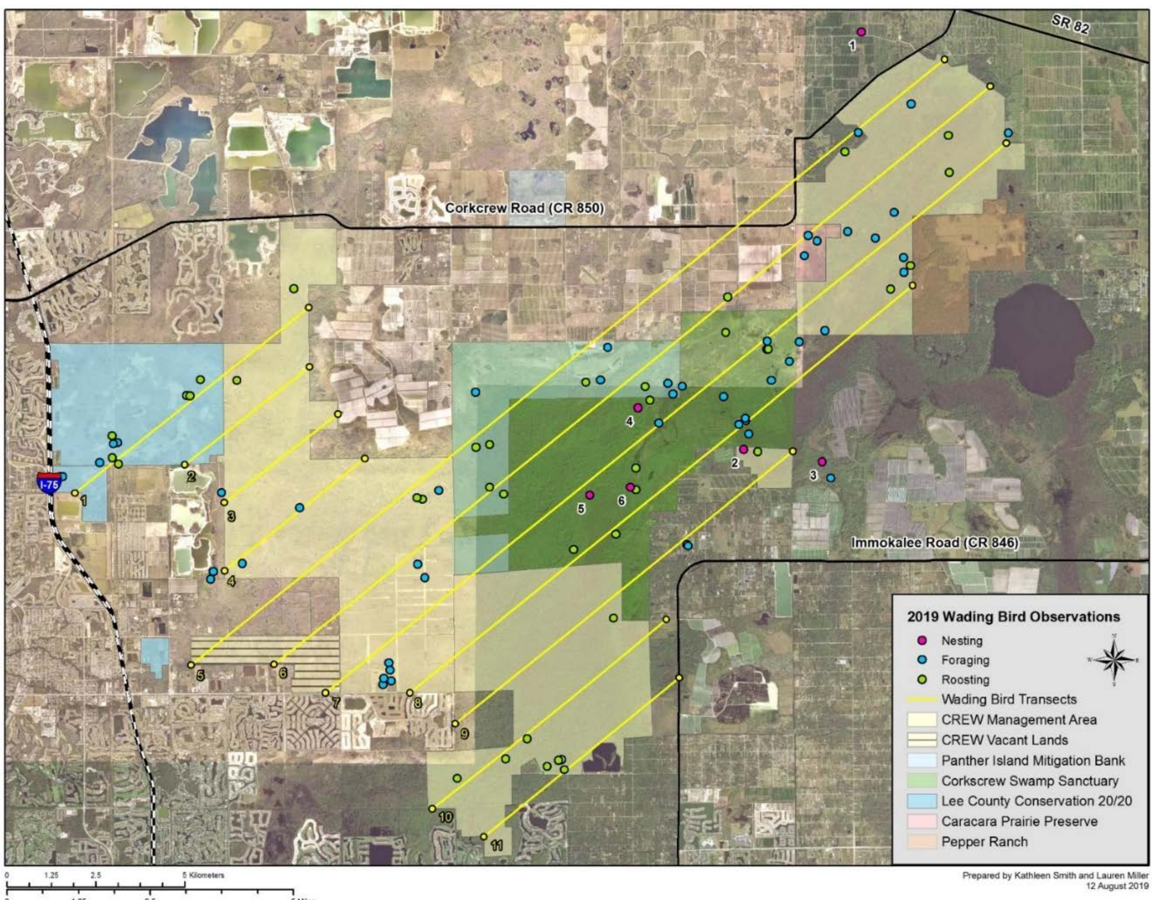

Figure 18. Locations of nesting, foraging, and roosting wading birds in and around the CREW Management Area and Corkscrew Swamp Sanctuary, January through June 2019. Colony 1 is Orange Grove, Colony 2 is Sod Farms, Colony 3 is Cypress East, Colony 4 is Corkscrew Swamp Sanctuary GREG, Colony 5 is Corkscrew Swamp Sanctuary WOST Subcolony 1, and Colony 6 is WOST Subcolony 3.

Table 14. Peak number of wading bird nests found near the CREW Management Area and Corkscrew Swamp Sanctuary, January to June 2019.

Colony	Latitude	Longitude	WOST	GREG	SNEG	CAEG	ROSP	TRHE	LBHE	GLIB	LGDA	SMDA	SMWH	Total
1	26.50040	-81.54440		20	8	1		2				1	6	**38**
2	26.39442	-81.57710			3	61		6	7	1	1		134	**213**
3	26.39132	-81.55490		16			1							**17**
4	26.40477	-81.60686				16			13					**29**
5	26.38254	-81.62037	3											**3**
6	26.38462	-81.60901	46											**46**
	Total		**49**	**36**	**11**	**78**	**1**	**8**	**20**	**1**	**1**	**1**	**140**	**346**

Colony 1 = Orange Grove; Colony 2 = Sod Farms; Colony 3 = Cypress East; Colony 4 = Corkscrew Swamp Sanctuary GREG; Colony 5 = Corkscrew Swamp Sanctuary WOST Subcolony 1; Colony 6 = WOST Subcolony 3.

WOST Subcolonies

This was the third consecutive year of WOST nesting at Corkscrew Swamp Sanctuary, but WOST peak nest counts declined 81% from 2018 (264 nests) to 2019 (49 nests). Nest initiation began in early to mid-December in WOST Subcolonies 1 and 3. WOST Subcolony 1 had a peak nest number of three and fledged two chicks in March.

WOST Subcolony 3 had a peak count of 46 nests on January 3, 2019, but by January 10, Corkscrew Swamp Sanctuary staff documented no active nesting and only 20 WOST present. During FWC's next flight on February 8, no WOST were present and no nesting effort was observed. It is unclear why the subcolony failed, but approximately 1.2 inches of rain fell from December 20 to 22, 2018, and the increased water levels may have been a factor in nest abandonment during this critical stage of early nesting.

Orange Grove

The Orange Grove peak nest number declined 46% from 2018 (**Table 14**). Nesting Great Egrets (GREG) were most abundant in the colony. GREG nesting peaked in May, which is later in the year than usual. Snowy Egrets (SNEG), Tricolored Herons (TRHE), and Cattle Egrets (CAEG) composed the remainder of the nesting birds, and nesting for these three species peaked in June. No nesting Anhinga (ANHI) were observed for the first time since surveys began in 2012-2013.

Sod Farms

The peak count for the Sod Farms colony increased 78% from 2018 (**Table 14**). Most of the colony consisted of nesting CAEG; however, TRHE, Little Blue Heron (LBHE), and SNEG also nested there in 2019. Species richness of nesting wading birds was the highest of all the monitored colonies in 2019 (five species). Despite the colony's species richness, nesting effort by LBHE has declined 89% from its peak in 2015 for unknown reasons. Nesting began in May and continued at least through June when surveys concluded.

Cypress East

Although no nesting effort was observed at the Cypress East colony in 2018 (the first time since surveys began), GREG began nesting in March, but abandoned their nests by the April flight. Only one ROSP nest remained, and it fledged two chicks in May. It is unclear why nesting effort has been impacted at this colony during the last 2 years (**Table 14**).

Corkscrew Swamp Sanctuary GREG

Corkscrew Swamp Sanctuary GREG colony nested for the sixth year since surveys began, though slightly south of its traditional location. Peak count increased 86% from 2018. Species composition of this colony continues to change each season. The 2019 colony was composed of nesting LBHE and CAEG, whereas GREG, GBHE, and ANHI previously nested in the colony. Nesting at this colony began in June.

Foraging and Roosting Effort

In addition to nesting colonies, 63 foraging aggregations and 41 roosting colonies were observed (**Figure 18**). White Ibis (WHIB) (1,495 birds), GREG (1,718 birds), SNEG (617 birds), WOST (261 birds), ROSP (192 birds), and CAEG (187 birds) were the most abundant species observed in foraging aggregations. WHIB and GREG were present in 68% and 43% of the foraging aggregations, respectively.

The most common species present in roosting colonies were GREG (observed in 66% of roosting colonies) and WHIB (observed in 54% of roosting colonies). Other species of interest, either foraging or roosting in CREW, included WOST, ROSP, SNEG, TRHE, LBHE, TRHE, American White Pelican (AWPE), and Black-crowned Night Heron (BCNH).

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WADING BIRD NESTING AT LAKE OKEECHOBEE

In May 2005, Florida Atlantic University (FAU) began monitoring the timing, size, and location of wading bird colonies at Lake Okeechobee as part of the Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan. In 2019, three focal species, Great Egret (GREG), Snowy Egret (SNEG), and White Ibis (WHIB), initiated an estimated 966 nests, which is 72% lower than the average since 2008 when the current lake schedule went into effect. Nest abundances were 41%, 64%, and 80% below average for GREG, SNEG, and WHIB, respectively. Nest abundances this season were the lowest since 2008 (20 nests), as nesting was limited almost entirely to small spoil islands and off-lake colonies due to dry conditions in the littoral zone. The Clewiston Spit (306 nests) and Gator Farm (230 nests) colonies, a spoil island and off-lake colony, respectively, supported the largest number of nests of these species.

METHODS

FAU personnel monitored the location, timing, and number of clutch initiations of wading bird nesting colonies on the lake from February to June 2019. Systematic aerial surveys were conducted monthly along transects covering the lake's littoral zone, with two dedicated observers surveying for nests of the five focal species: SNEG, GREG, WHIB, Wood Stork (WOST), and Roseate Spoonbill (ROSP). Counts and species composition of large colonies were verified by airboat. Estimates of nest initiation date were based on nest monitoring by boat at three spoil island colonies. More detailed methods are described in previous editions of the *South Florida Wading Bird Report*.

Rainfall and lake stage data were obtained from the South Florida Water Management District (SFMWD) DBHYDRO database. The lake stage is calculated as the mean of four gauges in the pelagic zone of Lake Okeechobee (L001, L005, L006, and LZ40). All elevation data are presented in National Geodetic Vertical Datum 1929 (NGVD29) and locations are in North American Datum 1983 (NAD83). Stage data from 2008 represents lake levels under the current Lake Okeechobee Regulation Schedule.

RESULTS

Hydrology

During the 2019 nesting season, Lake Okeechobee was characterized by a low lake stage, high recession rate, and two reversals preceding the seasonal rise in water levels in June (**Figure 19**). From January 1 to 26, the mean recession rate was 1.3 inches per week before unseasonal rainfall caused the lake stage to increase to a season high of 12.88 feet on February 20. The lake receded at a mean rate of 1.6 inches per week from February 21 to May 3, except for two minor reversals (<0.37 inches rise in stage per day) in late February and late March. Rainfall from May 4 to 14 caused the lake to rise at a mean rate of 0.1 inches per day before receding to the lowest lake stage of the season (and since 2011), 10.81 feet. The two major reversals during this season likely lowered prey availability and thus nest numbers. The first reversal may have impacted nest numbers as it occurred just before nest initiation for small herons at the lake. The low lake levels likely restricted GREG nest numbers as well because they have a strong negative relationship with lake stage.

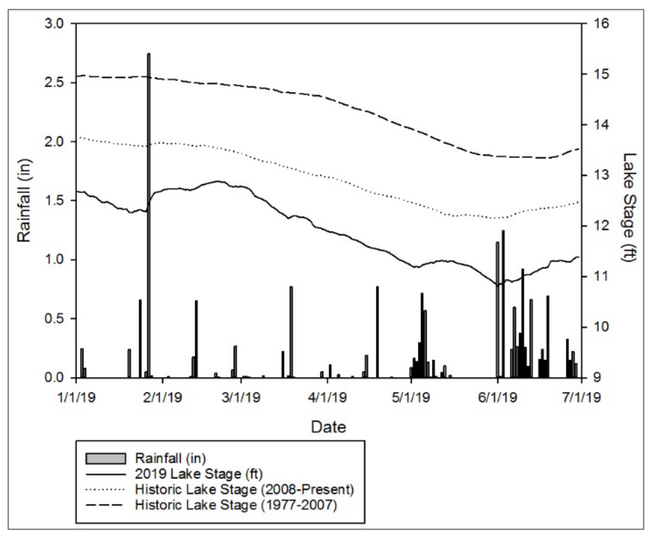


Figure 19. Hydrologic patterns in Lake Okeechobee from January to July 2019, and mean lake stages from 1977 to 2007 and from 2008 to present (i.e., since the 2008 Lake Okeechobee Regulation Schedule has been implemented).

Colony Location and Size

Eight colonies (**Figure 20**) supported a total of 966 nests of GREG, SNEG, and WHIB at Lake Okeechobee in 2019. This is 72% lower than the average from 2008 to 2019 (3,442 ± 1,984 nests; all averages use). Colonies were located at two natural willow colonies in the marsh (Moore Haven and Eagle Bay Island), four created spoil islands (Little Bear Beach, Clewiston Spit, Bird Island, and Pahokee Airport), and two off-lake created islands (Lakeport Marina and Gator Farm). Clewiston Spit was the largest colony, supporting 306 GREG, SNEG, and WHIB nests (**Table 15**). Peak nest abundance was 345 GREG, 430 SNEG, and 191 WHIB nests, which are the lowest nest abundances since 2008 (**Table 16**). GREG, SNEG, and WHIB nest abundance was 41%, 64%, and 80% lower, respectively, than average from 2008 to 2019 (599 ± 564 GREG nests; 1,199 ± 1,245 SNEG nests; 959 ± 1,040 WHIB nests). GREG and WHIB showed a similar decline in the Water Conservation Areas (72% and 38% below the 10-year average, respectively). However, SNEG nesting was a notable exception, with Everglades nest numbers being 4.2 times higher than the 10-year average. Despite low nest abundance for all species on the lake this year, the average abundance of GREG, SNEG, and WHIB nests remains higher under the current lake regulation schedule (3,442 ± 1,984 nests) compared to 1977 to 2007 (2,601 ± 2,364 nests).

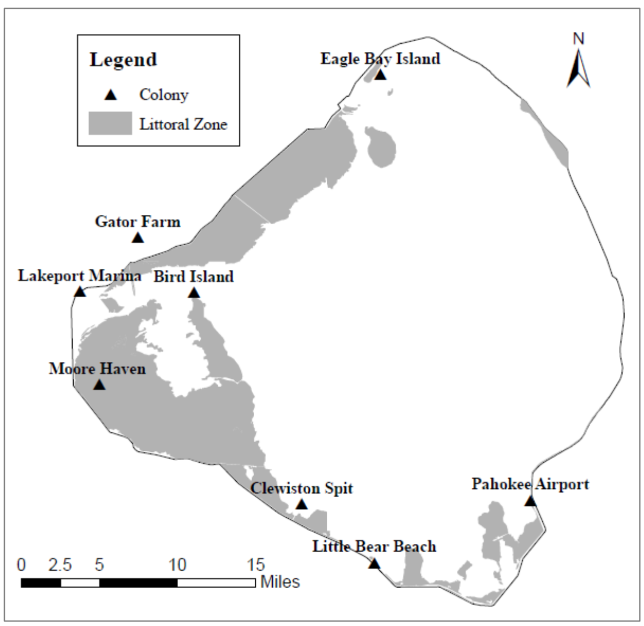


Figure 20. Map of wading bird colonies detected on Lake Okeechobee from February to June 2019.

Timing and Success

The median clutch initiation date was March 8 for GREG and March 3 for SNEG. This was 5 days earlier for GREG and 6 days earlier for SNEG than the average since 2009 (the period for which nest initiation data are available). Overall, apparent nest survival of GREG (50%) and small herons (SMHE; 63%) was 23% and 11% lower, respectively (0.65 ± 0.11 GREG; 0.71 ± 0.12 SMHE), than the average apparent survival from 2011 to 2019 (the period for which nest survival data are available). Apparent survival in 2011, a hydrologically similar year, was nearly identical for GREG (49%), but 11% higher for SMHE (70%).

Wood Storks and Roseate Spoonbills

Twenty-eight WOST nests and 20 ROSP nests were detected at Gator Farm, an off-lake colony north of Moonshine Bay. The majority of ROSP and WOST nests appeared to fail as only five fledglings of each species were detected in photos taken on May 19. WOST have nested at Gator Farm in 8 of the last 13 years (2007 to 2010 and 2016 to 2019), successfully fledging chicks every year nesting occurred. ROSP have nested at Gator Farm in low numbers (4 to 20 nests) for the past 3 years (2016 to 2019), successfully fledging chicks in 2018 and 2019.

The pattern of the presence and absence of WOST nesting on the lake is intriguing because it hints at a connection with the Everglades. The year WOST started nesting on the lake and the year they returned to nest after a 5-year absence were both years of very low WOST nesting in the Everglades. In 2010, WOST began nesting until they experienced poor success due to a lack of seasonal water level recession, followed by suboptimal dry hydrologic conditions the subsequent year. The importance of the lake as the core nesting area for SNEG is clear from this CERP Monitoring and Assessment Plan project, and the lake may serve as alternate nesting habitat for other species when poor conditions exist in the Everglades.

Table 15. Geographic coordinates (NAD83) and species-specific peak nest abundances in detected colonies during the 2019 breeding season at Lake Okeechobee.

Colony	Peak Month[1,2]	Latitude	Longitude	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	ANHI	Total[1]
Bird Island	March	26.97199	-81.00917			35			1		19				**55**
Clewiston Spit	April	26.77573	-80.90938	60	31	215			3		130	105			**544**
Eagle Bay Island	May	27.17427	-80.836672		160	30				15	40	118	400	12	**363**
Gator Farm	March	27.023004	-81.061103	200		30	28	20		11	+	12	400	10	**301**
Lakeport Marina	March	26.9726	-81.1144	25		10					6		550	4	**41**
Little Bear Beach	April	26.72139	-80.84222	50	40	130			1	1	75	100			**397**
Moore Haven	March	26.886412	-81.096436	10	30	30			1						**71**
Pahokee Airport	May	26.77908	-80.697596	3		20				1	40	1	35		**65**
	Total			**348**	**261**	**500**	**28**	**20**	**6**	**28**	**310**	**336**	**1,385**	**26**	**1,837**

[1] Does not include CAEG or ANHI.
[2] Peak month refers to the month during which combined nest effort peaked and does not refer to species-specific peak nest efforts.
\+ Species present and nesting but unable to determine number of nests.

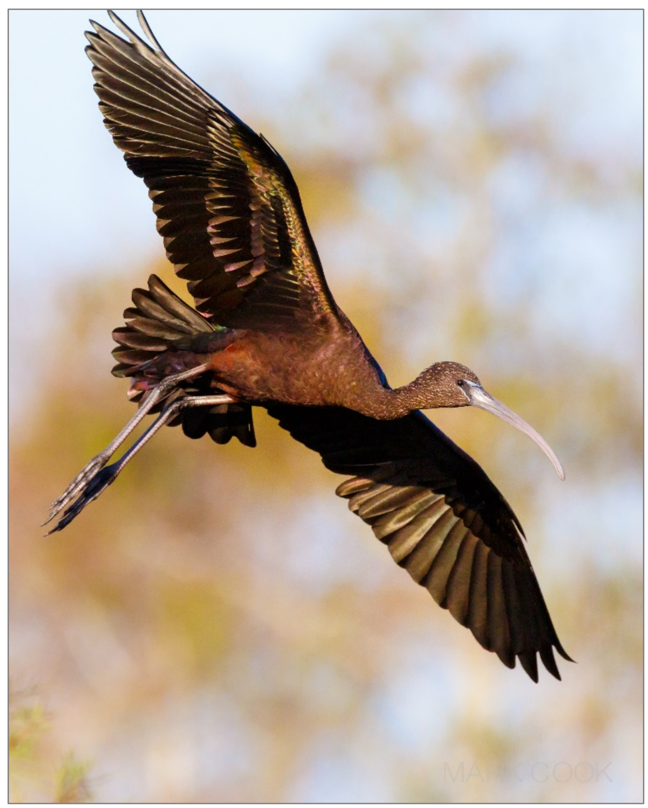
Table 16. Timing and nest numbers for species breeding in wading bird colonies at Lake Okeechobee in 2019.

Month	GREG	WHIB	SNEG	WOST	ROSP	GBHE	LBHE	TRHE	GLIB	CAEG	ANHI
February	45			10	10	**4**					
March	**345**		**430**	**28**	**20**	1		**250**			
April	95	71	412	12	**20**	1		197	**205**	395	
May	67	**191**	213	9	10		**26**	10	81	1,010	10
June	--[a]	127	40[a]		--[a]		13	20	202	**1,375**	**26**

[a] Large number of roosting birds present, but not on nests.
Note: Bold values denote peak nest effort for species.

Nesting in 2019 Compared to Other Years

Water level patterns in 2019 were similar to those in three of the five worst nesting years on record (1971, 1981, and 2007); therefore, low nesting this year was expected. Uncertainty lies in the nesting data pattern as a similar water pattern was seen in one good nesting year (2011). However, by incorporating a companion study of wading bird prey on the lake, 2011 had the highest prey density (164 ± 205 prey/m^2) of the 8 years sampled (80% above average, 91 ± 37 prey/m^2). In contrast, prey density (74 ± 138 prey/m^2) in 2019 was 19% below average, believed to be more typical of a relatively dry year.



Acknowledgments

Funding for nest monitoring was provided by the U.S. Army Engineer Research and Development Center and Florida Atlantic University with the support of RECOVER. We appreciate the support from our technicians for their dedication to difficult field work. We also benefitted from discussions with Mike Baranski at the South Florida Water Management District.

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KISSIMMEE BASIN

WADING BIRD NESTING

Wading bird nesting colonies within the Kissimmee River Restoration Area (KRRA) and Lakes Istokpoga and Kissimmee were not surveyed during the 2018-2019 dry season due to weather and helicopter flight scheduling conflicts (**Figure 21**).

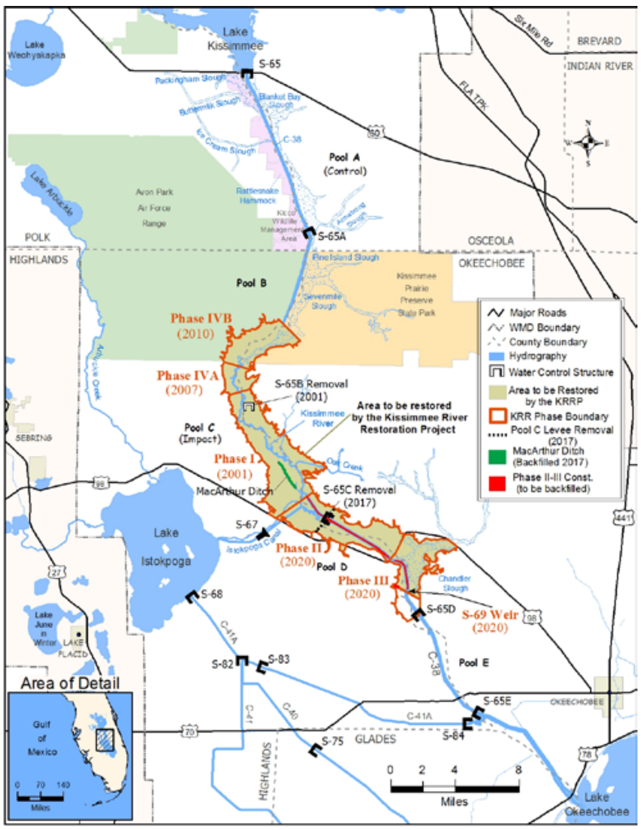

Figure 21. The Lower Kissimmee Basin, including the end dates of Kissimmee River Restoration Area (KRRA) construction phases.

WADING BIRD FORAGING ABUNDANCE

Birds are integral to the Kissimmee River floodplain ecosystem and highly valued by the public. The South Florida Water Management District (SFWMD) surveys wading bird nesting colonies and foraging wading bird abundance along the Kissimmee River as part of the Kissimmee River Restoration Evaluation Program (KRREP) (Williams et al. 2005a, 2005b). While quantitative pre-channelization data are sparse, available data and anecdotal accounts indicate the system supported an abundant and diverse bird assemblage, with several recurring breeding colonies of more than 1,000 nests (National Audubon Society 1936-1959, Florida Game and Fresh Water Fish Commission 1957). The Kissimmee River Restoration Project is expected to reproduce the necessary conditions to once again support such an assemblage.

To date, approximately 7,710 acres of wetland habitat (about half of the total project area) has been partially restored, and the interim response of foraging wading birds has exceeded the restoration expectation when averaged over the interim period (2001 to 2018) (Cheek et al. 2014, SFWMD 2018). While there is no formal expectation for wading bird nesting effort, the number and size of colonies that have formed along the river since restoration began in 2001 has been below historical levels (Williams et al. 2005a, Cheek 2016).

While foraging conditions on the floodplain can become optimal for wading birds during parts of the year, the current timing and magnitude of floodplain inundation and recession is not optimal for rookery formation due to constraints and other demands on water control operations that limit prey availability. All restoration construction is scheduled for completion by 2020, when implementation of the Headwaters Revitalization Schedule will allow water managers to more closely mimic the historical stage and discharge characteristics of the river, presumably leading to suitable hydrologic conditions at the appropriate spatial and temporal scales for wading bird nesting colonies. Wading bird responses to the river restoration project will be monitored for 5 years after construction completion. Detailed information regarding the breadth of the avian evaluation program and the initial response of avian communities to Phase I restoration can be found in Williams et al. (2005b) and Cheek et al. (2014). Detailed information regarding the interim response of wading birds and waterfowl to Phase I restoration can be found in Cheek et al. (2014).

As part of the KRREP, the following restoration expectation was developed for the abundance of foraging wading birds on the floodplain after construction:

- Mean annual dry season density of long-legged wading birds (excluding Cattle Egrets [CAEG]) on the restored floodplain will be ≥30.6 birds/km^2 (Williams et al. 2005a).

METHODS

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 (**Figure 21**). During weekly flights from November to May, a minimum of 20% 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 (TRHE) from adult Little Blue Herons (LBHE) during aerial surveys, the two are lumped together as "small dark herons". Likewise, Snowy Egrets (SNEG) and immature LBHE were classified as "small white herons".

RESULTS

Prior to the restoration project, dry season abundance of long-legged wading birds in the Phase I restoration area averaged (±standard error) 3.6 ± 0.9 birds/km^2 in 1997 and 14.3 ± 3.4 birds/km^2 in 1998. Since completion of Phases I, IVA, and IVB of restoration construction in 2001, 2007, and 2009, respectively, annual abundance has ranged from 102.3 ± 31.7 birds/km^2 to 11.0 ± 1.9 birds/km^2 (mean [2002 to 2019] = 41.5 ± 5.5 birds/km^2) (**Figure 22**). The long-term annual 3-year running mean (2002 to 2019) is 40.9 ± 3.4 birds/km², significantly greater than the restoration expectation of 30.6 birds/km² (t-test, $p = 0.005$; Williams et al. 2005b). However, only the 3-year running means for 2002 to 2005 and 2004 to 2006 were significantly greater than the restoration target of 30.6 birds/km² when examined on an annual basis (**Figure 23**). Mean monthly wading bird abundance within the restored portions of the river during the 2018-2019 season was 42.0 ± 7.8 birds/km², bringing the 3-year (2017 to 2019) running average to 37.8 ± 12.2 birds/km², not significantly greater than the restoration expectation of 30.6 birds/km².

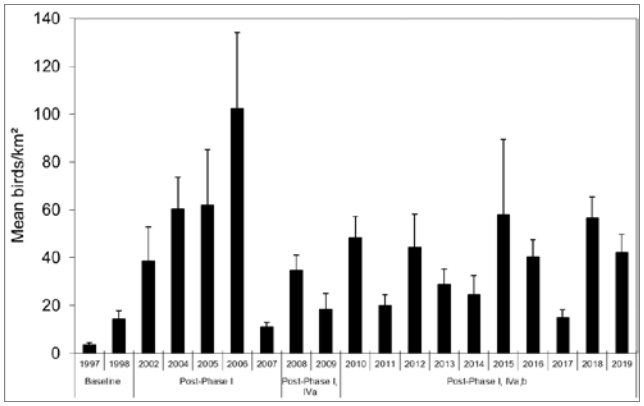

Figure 22. Baseline and post-Phases I, IVA, and IVB mean abundance ± standard error of long-legged wading birds/km² (excluding CAEG) during the dry season (December to May) within the 100-year floodplain of the Kissimmee River.

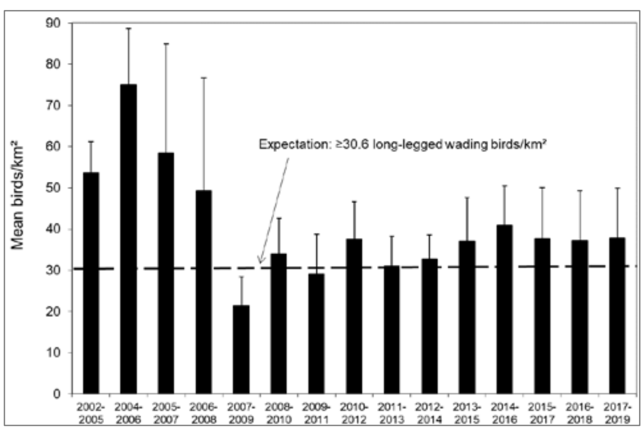

Figure 23. Post-restoration abundance as 3-year running averages ± standard error of long-legged wading birds/km² (excluding CAEG) during the dry season (December to May) within the Phase I, IVA, and IVB restoration areas of the Kissimmee River. Each 3-year running mean was not significantly different from the restoration target of 30.6 birds/km² when examined on an annual basis (t-test, SAS Institute 2011).

Rainfall during the 2018-2019 dry season was approximately average, while the preceding wet season was average in the Upper Kissimmee Basin (95% of average) and below average in the Lower Kissimmee Basin (71% of average). The below-average wet season rainfall in the Lower Kissimmee Basin led to below average floodplain depths at the start of the dry season (<0.25 feet deep on November 1) (**Figure 24**). This provided optimal foraging depths and prey availability across much of the floodplain during the November 13 survey flight, when the seasonal peak of 165 birds/km² was observed. However, the floodplain receded to an average of 0.07 feet by January 11, and bird numbers declined but remained above the restoration target of 30.6 birds/km² (SFWMD 2019).

Water depths on the floodplain began to increase with increased discharge out of S-65A starting around January 25, reaching a peak of approximately 1.3 feet deep on February 18. Wading bird numbers increased slightly during the February 12 survey with an influx of White Ibis (WHIB). WHIB possibly were taking advantage of newly available prey (terrestrial invertebrates) on the floodplain as it was inundated by the rising water. Bird numbers slightly rose again by the March 12 survey as flood waters receded to a depth of approximately 0.25 feet. Bird numbers declined during the final two surveys of the season (April 2 and May 21) as water level continued to recede.

As in previous years, WHIB dominated the surveys numerically (52.0%), followed in order of abundance by Great Egret (12.3%), small white herons (SNEG and juvenile LBHE; 9.1%), Wood Stork (8.7%), Glossy Ibis (5.9%), Great Blue Heron (5.4%), Roseate Spoonbill (2.9%), Black-crowned and Yellow-crowned Night Herons (2.4%), and small dark herons (TRHE and adult LBHE; 1.4%).

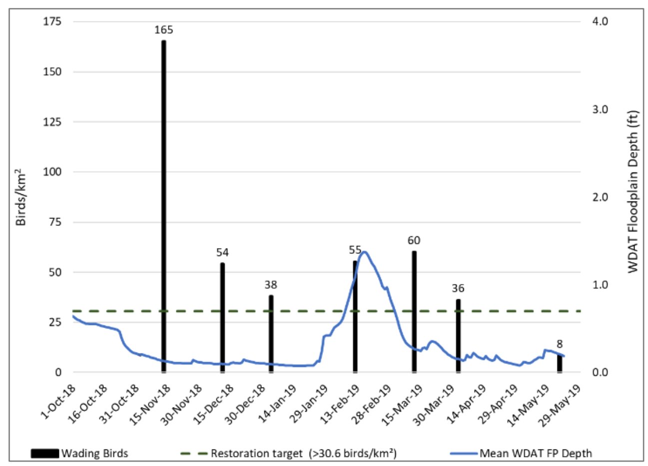

Figure 24. Wading bird abundance and mean floodplain depth in the Kissimmee River Restoration Area (Phases I, IVA, and IVB) during the dry season (December to May) 2019. Floodplain depth was obtained from the South Florida Water Depth Assessment Tool (SFWMD 2019).

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SAVANNAS PRESERVE STATE PARK

The Savannas Preserve State Park is a 5,000-acre property in northern Martin County and southern St. Lucie County, situated just west of the Indian River Lagoon. The property is bisected by an oligotrophic, linear basin marsh system (**Figure 25**) that stretches from Jensen Beach to southern Fort Pierce. It is the longest contiguous freshwater marsh system of its kind remaining in southeastern Florida, spanning approximately 10 miles north to south. The western preserve is dominated by a pine flatwood community with numerous depression marshes and wet prairie. The eastern preserve is along the Atlantic Coastal Ridge and typically dominated by sand pine scrub and scrubby flatwood communities. The marsh and associated wetlands provide a stopover for migrating birds and support nesting activities in small tree islands and dense sawgrass patches.

Figure 25. Aerial view of Savannas Preserve State Park basin marsh (Photo credit: Paul Milette).

During late February 2019, park staff surveyed a historical wading bird rookery (North Marsh). This colony, along with two others to the south, originally were surveyed between 1995 and 2003 by the South Florida Water Management District. Surveys were conducted in 2016 and 2018; however, drought conditions in 2017 prevented survey of the site due to low nest numbers and lack of access.

Basin marsh hydrological conditions are driven primarily by annual rainfall patterns and influenced by local runoff. Rainfall accumulation peaked near 11 inches in June 2019. The 2-week event was not enough to inundate the marsh system. Prior to the July 2019 rains, the basin marsh was in a drying trend from July 2018.

METHODS

The North Marsh Rookery is a shrub island within the basin marsh north of Walton Road, just north of the canoe launch area. This island primarily consists of pond apple and wax myrtle with sawgrass edges. Surveys were completed by canoe along the island's western edge. This site was surveyed from February through June, with peak nesting in June.

RESULTS

Nest numbers in 2019 appear similar to those from 1995 to 2003, 2016, and 2018 (**Table 17**).

FUTURE PLANS

Plans are to continue surveys at the North Marsh Rookery and observe any notable nest numbers on the South Marsh Rookery (27.2769, -80.2474) between January and July 2020.

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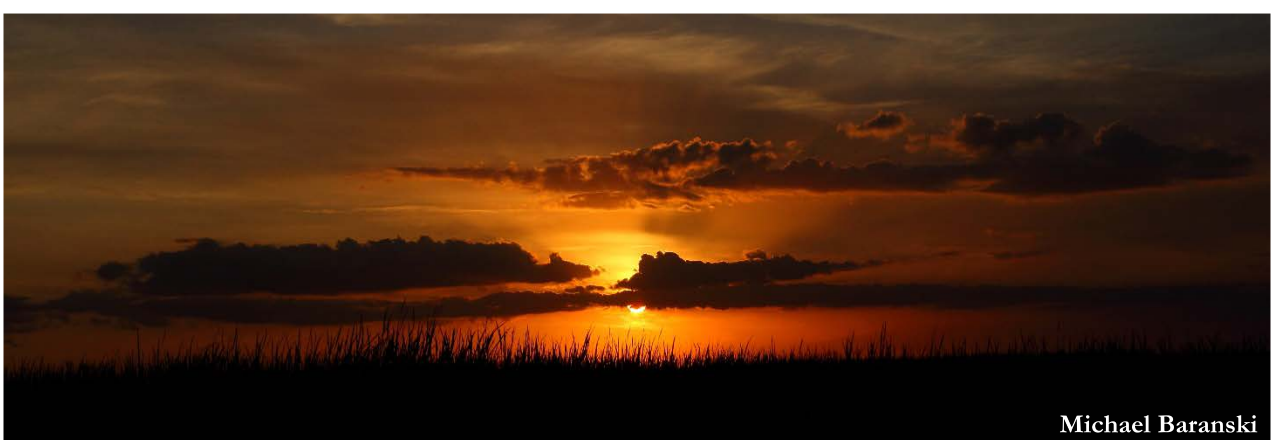
Table 17. Peak nest counts for each wading bird species in Savannas Preserve State Park.

Year	Colony	Latitude	Longitude	GREG	CAEG	GBHE	LBHE	ANHI	Total
2019	North Marsh Rookery	27.3117	-80.2713	6	8	12	3	14	**43**

Note: SNEG, BCNH, WHIB, and GLIB nests were not observed (count = 0).



SOUTHEAST FLORIDA (VARIOUS LOCATIONS)

METHODS

Florida Fish and Wildlife Conservation Commission (FWC) staff and volunteers conducted nest counts at eight wading bird colonies throughout FWC's south region in 2019. Nest numbers for Wood Stork (WOST) were low this year, and productivity was nearly zero. A very rainy dry season likely contributed to the poor nesting season.

Bird Island Critical Wildlife Area (27.190821, -80.187908) is a spoil island in the Indian River Lagoon. The island is closed to public access year-round to protect nesting and roosting birds. It is cooperatively managed with Martin County and monitored monthly throughout the year. Nest counts were conducted from a boat circling the island, and it is certain that some interior nests were not counted.

BallenIsles (26.830148, -80.109158) is a small island located on a lake within the BallenIsles Country Club golf course. Nest counts were conducted on foot from vantage points on the north and south sides of the golf course. Only WOST and Tricolored Herons (TRHE) were counted, but other species were present.

The Solid Waste Authority of Palm Beach County (26.770188, -80.125313) has multiple spoil islands in abandoned shell pits that were mined in the early 1960s. Counts were done by boat, and it is certain that some interior nests were not counted. More than 14 different species and more than 1,000 adult White Ibis (WHIB) were present during the surveys. Survey efforts were focused on WOST and state-listed species.

Wakodahatchee Wetlands (26.479889, -80.142326) is a manmade wetland where many wading bird species nest. WOST and other species were counted from the boardwalk, but not all species present were recorded.

Sawgrass Ford (26.149837, -80.337621) is a spoil island behind the Sawgrass Ford dealership in Sunrise. Nest counts were conducted by circling the island in a kayak.

Griffin (26.063633, -80.366492) is in Emerald Estates Park. Surveys were done from the road on the south side of the colony. Nests on the east side likely were not counted.

ABC Islands Critical Wildlife Area (25.063633, -80.366492) encompasses three spoil islands on the eastern side of Marco Island. The islands are closed to public access year-round to protect nesting, migrating, and wintering birds. This site is cooperatively managed and monitored with Rookery Bay National Estuarine Research Reserve. Counts were conducted by boat circling each island, and it is certain that some interior nests were not counted.

The East River Wading Bird Rookery is located within Fakahatchee Strand Preserve State Park (25.929755, -81.444512). This rookery has never been included in the annual wading bird report but has existed for many years. This year, FWC staff as well as the Park Biologist did one nesting survey in July. Nest counts were conducted by circling islands in a canoe or kayak.

RESULTS

Nest count data from each region are presented in **Table 18**.

Table 18. Peak numbers of nests at various locations from January to June 2019.

Colony	ANHI	BCNH	CAEG	DCCO	GBHE	GLIB	GREG	GWHE	LBHE	REEG	ROSP	SNEG	TRHE	WHIB	WOST
Bird Island CWA	2			10	1						2		1		11
Ballen Isles	+	+	+	+	+	+	+		+	+	+	+		+	10
Solid Waste Authority	+	+	+	+	+	+	2			+	25	5	6	63	135
Wakodahatchee Wetlands	53		1	5	9	4	10					3	9		82
Sawgrass Ford	6			9			2						9		39
Griffin	6		36				3					1	3		22
ABC Islands CWA	1		1	28	11		83	2	1	2		11	9		
Rookery Bay NERR									2			19	21		
Total	**68**		**38**	**52**	**21**	**4**	**100**	**2**	**3**	**2**	**27**	**39**	**58**	**63**	**299**

+ Present but not counted.

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J.W. CORBETT WILDLIFE MANAGEMENT AREA

This year, J.W. Corbett Wildlife Management Area staff conducted two aerial surveys of wading bird colonies to determine their location and size as part of the Florida Fish and Wildlife Conservation Commission's Wildlife Conservation Prioritization and Recovery Program.

METHODS

On April 16 and May 31, systematic aerial surveys were conducted to locate colonies and estimate numbers of nesting wading birds. Two observers sat on either side of a helicopter traveling at an altitude of 300 to 400 feet and a speed of 40 to 60 knots. Transects were spaced 1.25 km apart and oriented in an east-west direction. Digital photos were taken to help obtain accurate estimates of numbers of birds.

RESULTS

Peanut Pond

One colony was observed at Peanut Pond. This colony occupies a willow head (26.84195, -80.3225) covering approximately 1.2 acres. Peak nest counts are reported in **Table 19**.

Table 19. Species-specific nest count during the 2019 breeding season at J.W. Corbett Wildlife Management Area.

Colony	ANHI	BCNH	CAEG	GBHE	GREG	LBHE	SNEG	TRHE
Peanut Pond	9	+	110	+	35	12	+	+

+ Species was observed but nest count could not be determined.

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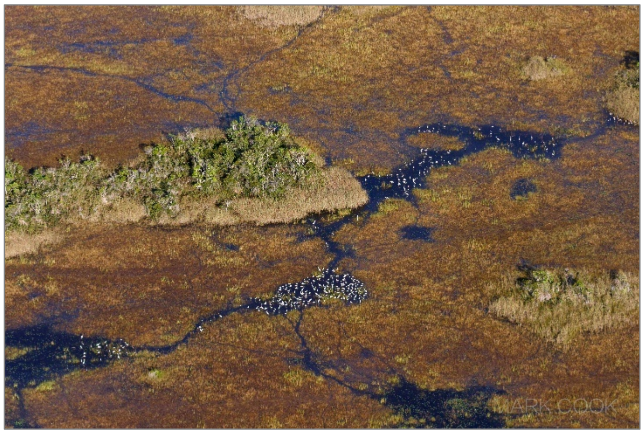
PALM BEACH COUNTY NATURAL AREAS

Staff at Palm Beach County's Environmental Resources Management surveyed wading bird colonies in natural areas between January and May to assess nesting efforts. This included four known locations within the Pine Glades, Loxahatchee Slough, and Cypress Creek natural areas. Three of the four known colonies had no nesting this year; only the Northeast Loxahatchee Slough colony had nesting this year.



METHODS

The site was surveyed on May 1. The colony is located in a matrix of pine flatwoods, marsh, and cypress swamp habitats. The 1.4-acre colony consists of two deepwater pond apple and willow heads within a larger cypress dome. From the ground, staff recorded the number of nests. Counts were from multiple vantage points encircling the colony to ensure full coverage.

RESULTS

Nest counts in 2019 were similar to those from 2018. Nest counts for the Northeast Loxahatchee Slough Colony are provided in **Table 20**.

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Table 20. Peak number of wading bird nests by species observed in the Loxahatchee Slough Natural Area.

Colony	Latitude	Longitude	CAEG	LBHE	TRHE	Total
Northeast Loxahatchee Slough	26.89205	-80.17307	6	63	5	**74**

STATUS OF WADING BIRD RECOVERY

The sustainability of healthy wading bird populations is a primary goal of the Comprehensive Everglades Restoration Plan (CERP) and other Everglades restoration programs. A 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 (Frederick et al. 2009). There are at least two overlapping sets of measures to attain these conditions, all based on historical conditions and thought to be representative of key ecological features of the bird-prey-hydrology relationship. The Restoration Coordination & Verification (RECOVER) program established Performance Measures (PMs) (http://www.evergladesplan.org/pm/recover) that include 3-year running averages of the numbers of nesting pairs of key avian species in the mainland Everglades, the timing of Wood Stork (WOST) nesting, and the proportion of the population that nests in the coastal ecotone (Ogden et al. 1997). In addition to these three PMs, the annual Stoplight Reports have two other PMs: the ratio of visual to tactile wading bird species breeding in the Everglades, and the frequency of exceptionally large White Ibis (WHIB) breeding events. These PMs were added in an attempt to further capture key ecological relationships found in the historical ecosystem (Frederick et al. 2009). This section reports on the long-term trends and current status of all these PMs. When thinking about progress towards these restoration measures, it should be remembered that the hydrological system is not yet restored to provide anything like the ecological functions expected in a completed CERP. While 2018 moved the needle considerably in most measures, the 2019 season was comparatively disappointing. Based on the recent status of the hydrological system, restored or even partially restored wading bird population indicators would not have been predicted.

The main indicator species are Great Egret (GREG), Snowy Egret (SNEG), WHIB, and WOST. Although the Tricolored Heron (TRHE) originally was included in this list (Ogden et al. 1997), this species has proven extremely difficult to consistently monitor due to the inability to see their dark plumage during aerial surveys. Ogden et al. (1997) combined TRHE and SNEG population targets (e.g., 10,000 breeding pairs), and it is difficult to derive an expected number for SNEG alone (Ogden 1994). Based on relative abundances in coastal colonies (Ogden 1994), roughly equal support can be derived for 1:1 ratios as for 2:1 ratios (SNEG:TRHE). In practice, the distinction is unimportant as both species appear to be declining and are nowhere near any of the population restoration targets. Here, data are summarized for the three Water Conservation Areas (WCAs) and mainland Everglades National Park (ENP).

RESTORATION METRICS

Numbers of Nesting Pairs

The 3-year running average for nesting pairs in the mainland Everglades (2017 to 2019) are 7,965 GREG pairs, 2,856 SNEG pairs, 44,967 WHIB pairs, and 2,282 WOST pairs (**Table 21**). Trends for GREG over time for this PM increased markedly from 1988 to 2004, and have been roughly stable since, with the 3-year running average meeting or exceeding restoration criteria for 23 consecutive sampling periods since 1996. Trends for SNEG also increased markedly from 1986 to 2004, dropped dramatically from 2005 to 2017, and then rebounded considerably during the 2018 and 2019 nesting seasons. Generally, big nesting years for flock-foraging species show a big increase in SNEG nesting. Nonetheless, 3-year running averages of breeding SNEG have been consistently below the target restoration goal since monitoring began in 1986. The 3-year running average has increased markedly (2.7 times) for WHIB between 1986 and 2001, then remained variable but arguably stable for nearly a decade (2002 to 2011). The final period in this record (2011 to 2018) showed substantial fluctuation in WHIB nesting, with a 50% reduction in 3 years, and 3 of the 5 years in that period being well below the average of the previous decade. The huge nesting effort in 2018 pulled the running average up considerably, and the running average may remain high for the next 3 years simply because of the contribution of 2018. WHIB nesting populations have met or exceeded the breeding population criterion every year for the past 20 years. WOST showed a notable increase from averages in the 2- to 300-pair range (1986 to 1992) to averages above 1,000 pairs in many years after 1999. WOST have equaled or exceeded the restoration population criterion during 10 of the last 19 years, including 2019.

Table 21. Three-year running averages of the number of nesting pairs for the five indicator species in the Everglades. Bolded years are those that meet minimum criteria.

Period	GREG	SNEG	WHIB	WOST
1986-1988	1,946	1,089	2,974	175
1987-1989	1,980	810	2,676	255
1988-1990	1,640	679	3,433	276
1989-1991	1,163	521	3,066	276
1990-1992	2,112	1,124	8,020	294
1991-1993	2,924	1,391	6,162	250
1992-1994	3,667	1,233	6,511	277
1993-1995	3,843	658	2,107	130
1994-1996	**4,043**	570	2,172	343
1995-1997	**4,302**	544	2,850	283
1996-1998	**4,017**	435	2,270	228
1997-1999	**5,084**	616	5,100	279
1998-2000	**5,544**	1,354	**11,270**	863
1999-2001	**5,996**	2,483	**1,655**	**1,538**
2000-2002	**7,276**	6,455	**23,983**	**1,868**
2001-2003	**8,460**	6,131	**20,758**	**1,596**
2002-2004	**9,656**	6,118	**24,947**	1,191
2003-2005	**7,829**	2,618	**20,993**	742
2004-2006	**8,296**	5,423	**24,926**	800
2005-2007	**6,600**	4,344	**21,133**	633
2006-2008	**5,869**	3,767	**17,541**	552
2007-2009	**6,956**	1,330	**23,953**	1,468
2008-2010	**6,715**	1,723	**21,415**	**1,736**
2009-2011	**8,270**	1,947	**22,020**	**2,263**
2010-2012	**6,296**	1,599	**11,889**	1,182
2011-2013	**7,490**	1,299	**16,282**	**1,686**
2012-2014	**7,041**	1,017	**17,194**	**1,696**
2013-2015	**6,300**	710	**21,272**	**1,639**
2014-2016	**5,328**	837	**17,379**	995
2015-2017	**5,655**	639	**17,974**	1,195
2016-2018	**8,803**	1,224	**41,465**	**2,152**
2017-2019	**7,965**	2,856	**44,967**	**2,282**
Target Minima	4,000	10-20k	10-25k	1.5-2.5k

Together, these statistics illustrate that there has been a very substantial increase in numbers of GREG, WOST, and WHIB since 1986, followed by a period of relative stability, during which each species has met restoration targets in many or most years. While SNEG appear to be rebounding in the last 2 years, this species has never met restoration targets. In addition, there is evidence from systematic ground surveys in WCA-3 (see *Hydrologic Patterns for Water Year 2019* section) that breeding populations of the other two small herons in the genus *Egretta* (TRHE and Little Blue Herons [LBHE]) also are declining sharply in the Everglades.

Coastal Nesting

More than 90% of indicator species nesting is estimated to have occurred in the southern coastal ecotone region during the 1930s and early 1940s, likely because this was the most productive area. A major restoration hypothesis holds that it is the reduction of freshwater flows to the coastal region that has reduced secondary productivity and resulted in the abandonment of the area by nesting wading birds. The proportion of the entire mainland Everglades nesting population that nests in the coastal zone is one of the restoration indicators, with at least 50% of nesting as the restoration target (Ogden et al. 1997). This PM has shown considerable improvement since the lows of the mid-1990s and early 2000s (2% to 10%; **Figure 26**), and during the last several years has ranged between 15% and 41%. In 2019, 42% of all nests were in ENP, which is the highest number since records of this metric began in 1986. This metric is not yet meeting the target of 50%, but the trend has been improving in recent years.

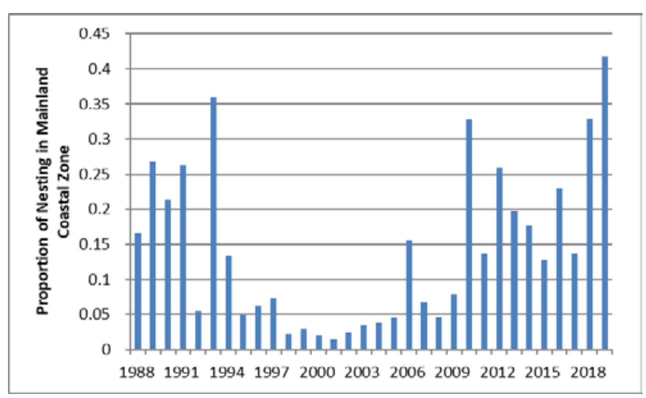

Figure 26. Proportion of all mainland Everglades nests located in the coastal estuarine zone, 1986 to 2019.

Ratio of Visual to Tactile Foragers

This PM recognizes that the breeding wading bird community has shifted from being numerically dominated by tactile foragers (WOST and WHIB) during the pre-drainage period to one in which visual foragers such as GREG are numerically dominant. This shift is thought to have occurred as a result of impounded, stabilized, or over-drained marsh, which leads to the declining availability of larger forage fishes (for WOST) and crayfishes (for WHIB). These conditions also seem to favor species like GREG that are less reliant on the entrapment of prey and can forage both in groups and solitarily under a variety of circumstances. Restoration targets are set at 32 breeding tactile foragers to each breeding visual forager, characteristic of the 1930s breeding assemblages. While this measure has shown some improvement since the mid-1990s (movement from 0.66 to 7.9), the ratio is still an order of magnitude less than the restoration target (**Figure 27**). The 5-year running average for this PM in 2019, however, was the highest at any point since the 1980s, at 5.02. This was largely due to high proportions in 2018 and 2019.

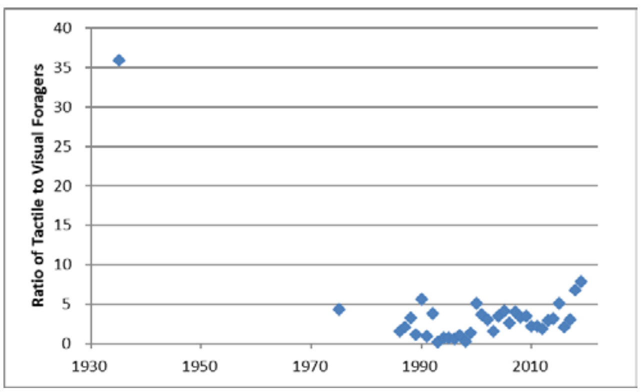

Figure 27. Ratio of tactile feeding species (ibis +stork) nests to sight foraging (GREG) nests in the Everglades, 1930 to 2019.

Timing of Nesting

This PM applies only to the initiation of nesting for WOST, which has shifted from November-December (1930s through 1960s) to January-March (1980s to present). Later nesting increases the risk of mortality of nestlings that have not fledged prior to the onset of the wet season and can make the difference between the South Florida WOST population being a source or sink population. This PM has shown a consistent trend towards later nesting between the 1930s and 1980s, with variation around a February mean initiation date since the 1980s (**Figure 28**). Although some years in the mid-2000s stimulated earlier nesting, there has been no lasting improvement. The 2018 season start (late December) was quite early compared to recent years and was only one of three years in the last 30 year in which WOST have initiated nesting by the end of December. The 2019 date was mid-January, which is better than most of the dates in the last 10 years. The 4-year running average for 2019 was 2.7, which corresponds to an average nest initiation date of late January or early February. This metric has seen steady improvement since 2016.

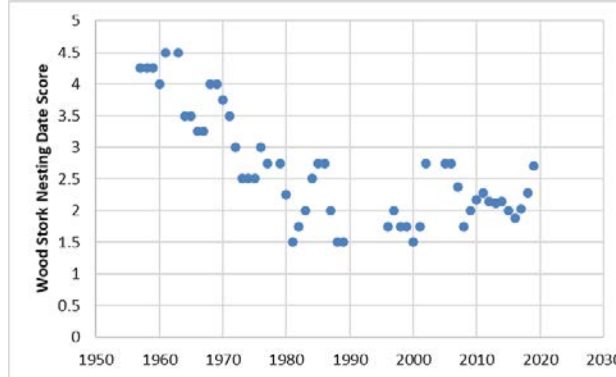

Figure 28. Four-year running average of WOST nest initiation date in the Everglades. Initiation in March is a 1, initiation in November is a 5.

Exceptionally Large Ibis Aggregations

Episodic, exceptionally large breeding aggregations of WHIB were characteristic of the pre-drainage system and are thought to be indicators of the wetland system's ability to produce very large pulses of prey, resulting in part from typical cycles of drought and flood. Large breeding aggregations during the recent period are defined as more than 16,977 nests each year (the 70th percentile of the entire period of record of annual nests). The interval between large WHIB nesting efforts in the pre-drainage period was 1.6 years, and this serves as the target for restoration. This PM has markedly improved since the 1970s, with the target achieved in 11 of the last 12 years. The 2019 WHIB nesting reached the restoration criterion, and the interval averaged over the last 5 years is 1.4 years, slightly more frequently than in the 1930s.

DISCUSSION

As a whole, these wading bird nesting PMs suggest that while there have been real improvements during the past one or two decades, several key PMs are stalled and not showing further improvement. Two PMs are promising: numbers of nesting pairs of WHIB, WOST, and GREG in the system seem to be regularly achieving the restoration targets, and the interval between exceptional WHIB nesting years has consistently met the restoration target. Additionally, there has been progress in the location of nesting, with dramatic increases in 2018 and 2019. Nonetheless, there is much room for improvement, especially in the multi-year mean. While the numbers of SNEG have improved over the last 2 years, they remain far from restoration targets. There is fairly paltry evidence that the timing of WOST nesting is improving on average, despite early nesting in 2017 and 2018. The ratio of tactile to visual foragers has improved since the mid-2000s but remains an order of magnitude below the restoration target.

This clearly illustrates that wading birds probably have responded in the last two decades to a combination of altered water management regimes, good weather, and hydropattern by nesting more consistently in the coastal zone, and by increasing populations of WHIB and WOST. While some of the WHIB and WOST population increases may be attributable to forces outside the Everglades system, the fact that these species have been attracted to nest in the Everglades in larger numbers, and that nesting often has been successful, remains a solid indicator. The lack of movement of the other PMs suggests the current management regimes are not powerful enough to nudge the timing of nesting, ratio of visual to tactile foragers, or numbers of nesting SNEG further. While this suggests an apparent stasis, it should be remembered that full restoration of wading bird populations is predicted only as a result of full restoration of key historical hydropatterns, which has not yet occurred.

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