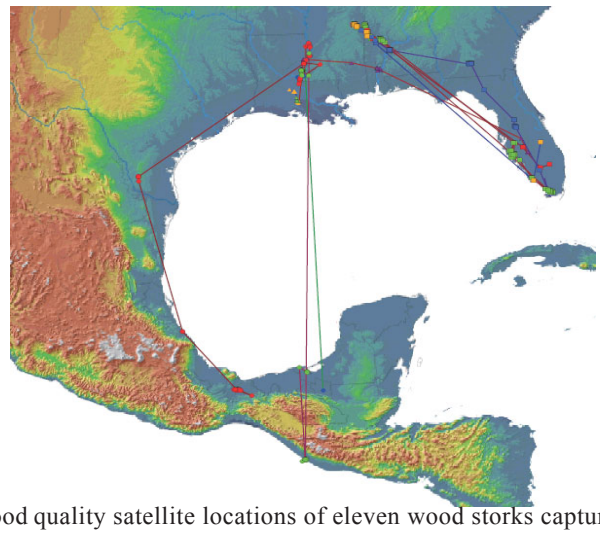

Wayne Lasch

U.S. Fish & Wildlife Service

Wood Stork Report

A newsletter dedicated to sharing information about the wood stork.

Volume 3, Number 1 April 2004



Good quality satellite locations of eleven wood storks captured in Mississippi and Lousianna during the summersof 2002 and 2003.

Gulf Coast Tracking Project Update

Larry Bryan (SREL), Billy Brooks (USFWS), Clint Jeske (USGS), David Richardson (USFWS) and Jimmy Taylor (USDA)

The Wood Stork in Mississippi is thought to be part of the western population (from Mexico) which is not protected by the ESA. However, extensive anecdotal information suggests that both eastern (southeast U.S.) and western (Mexican) populations mix during the summer in Mississippi. In the summer of 2004, as part of an multi-agency effort to examine origins of Wood Storks observed in Gulf Coast states, 10 satellite transmitters were deployed on storks: 3 in southern Louisiana, 4 in western Mississippi, and 3 in eastern Mississippi. Four of these were larger (45 g) transmitters that are still emitting signals and 6 were smaller (20 g) transmitters that have largely ceased functioning at the present time (December 2003). Of these 6, one deployed on an eastern MS stork "migrated" to southern FL prior to transmitter failure. It is possible that another stork with a small transmitter, deployed in Louisiana, migrated to eastern Mexico (west of the Yucatán peninsula), but the signal quality of this location is poor. The remaining small transmitters documented movements of storks within the vicinity of their capture sites prior to transmitter failure/signal cessation.

The four larger transmitters continue to perform well. Stork 40777, stayed in the vicinity of its eastern MS capture site (Noxube NWR & adjacent western AL) until mid-October, when it moved into southern GA. In late November, this stork moved into northern FL and is currently in Sumter Co. (central), FL. The storks captured at the St. Catherine's Creek NWR in western MS, 40778 and 40779, migrated to Mexico in early and late October, respectively. Stork 40778 is currently

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Survival and Movements of Juvenile Wood Storks

Becky Hylton (becky_hylton@hotmail.coom) (UF) and Peter Frederick (pcf@mail.ifas.ufl.edu) (UF)

This was the second year of study examining factors that may affect the survival of juvenile Wood Storks, *Mycteria americana*. Wood Storks are of special interest with regard to the restoration of the South Florida Ecosystem, both because wetlands of south Florida are considered prime habitat for this federallyendangered species and because the storks' demographic responses are thought to be indicators of several aspects of normal ecosystem function. As the first few months of a bird's life are often the period of time when birds may experience their highest mortality, we examined health and body condition of Wood Stork nestlings prior to fledging. Storks nesting in south Florida are actually a fluid subset of the larger southeastern U.S. population, yet the movements of these birds and the specific habitats they use remain poorly understood. This study of the movement-dependent survival of individual storks may therefore lead to the identification of specific wetland areas used most heavily, and those that are most valuable.

We worked in the Tamiami West colony in Everglades National Park during both 2002 and 2003 as this colony was centrally located in the Everglades ecosystem, hosted a large number of nesting Wood Storks (>400 pairs), and had stork nests easily reachable

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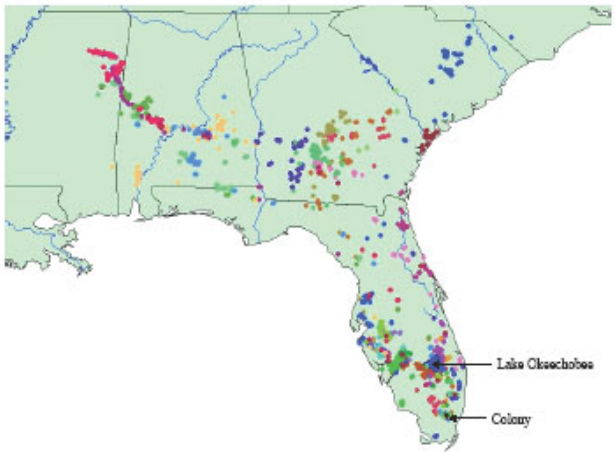


Figure 1. All good quality satellite transmitter locations of juvenile Everglades Wood Storks between 15 May and 6 Oct 2002. Each color represents a different individual.

The Wood Stork Report

Billy Brooks (USFWS) (*billy_brooks@fws.gov*)

As with most endangered and threatened species, the Wood Stork has a network of people who have mutual goals, mandates, inherent missions, and personal interests to promote and monitor this endangered species' recovery. This web-based newsletter is an effort to recognize the dedication of these people and their organizations' efforts in Wood Stork recovery. This newsletter also serves as a location to exchange information on Wood Stork recovery, research, monitoring, and management. It is our goal to publish this newsletter annually following the Wood Stork Research and Monitoring Working Group annual meeting. Email contact information for our recovery partners is noted in the newsletter. To submit an article or other information regarding Wood Stork recovery, please email *billy_brooks@fws.gov*.

***...Gulf Coast Tracking Project Update** continued from page 1*

on the Pacific side of Mexico near the Mexico/Guatemala border while stork 40779 is in eastern Mexico near the Yucatán peninsula. The stork from southern Louisiana, 40776, moved eastward into AL in mid-September. It remained on the Tom Bigby Waterway north of Mobile, AL until early December, when it migrated to central FL (between Tampa and Lake Kissimmee). Stork 40776 is the only non-adult with a large transmitter.

We should continue to receive signals on the four larger transmitters at least until mid-summer of 2004. This project is a joint effort of the U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S.D.A. National Wildlife Research Center, and the University of Georgia's Savannah River Ecology Laboratory.

St. Martinville, Louisiana Captures

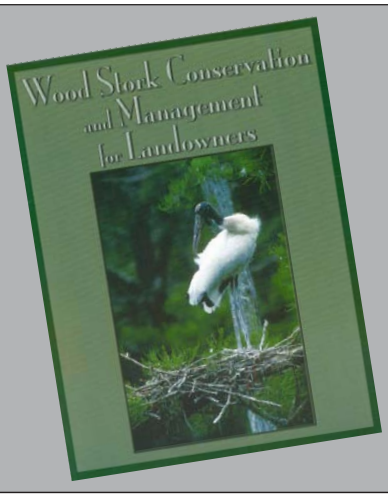
We set up to capture storks in Louisiana on June 30 at privately-owned capture sites. Our capture sites were a series of draining crayfish impoundments and their associated wetlands between St. Martinville and the Atchafalaya Basin. Literally thousands of wading birds, including storks, were present each day on these large (hundreds of acres in size) impoundments. One difficulty with a capture attempt in draining wetlands of this size is knowing what part of the impoundments the storks will be utilizing. We captured five storks with a rocket net shot the first day, but deployed only one transmitter on a 2nd year sub-adult stork. The remaining storks were first-year juveniles that were banded and released. The remaining two transmitters were deployed on sub-adult storks that were captured with padded leg-hold traps on the third day.

Noxubee National Wildlife Refuge Captures

Stork capture at Noxubee National Wildlife Refuge on the eastern edge of the state took place in June 2003. Noxubee NWR and USDA-NWRC personnel established several rocket-netting sites on the refuge on a 200-acre moist-soil complex. To enhance capturing storks, water in two impoundments was reduced to a small area not much larger than a 20-foot puddle to concentrate fish. Silhouette stork decoys were placed along the edges of the water to entice the birds within the netting area with the main objective being to capture and place satellite transmitters on 3 adult birds. On the first day, only 1-2 juveniles appeared, but on the second day, 12 Wood Storks and 30 other wading birds were captured with one shot. This was the largest single capture of storks to date. Three adults were fitted with transmitters and the other 9 birds were leg banded and released on a nearby open-water pool.

St. Catherines Creek National Wildlife Refuge Captures

Efforts to capture storks along the western edge of Mississippi ocurred in the delta region at St. Catherine's Creek National Wildlife Refuge near Natchez. Receding backwater of the Mississippi River creates a haven for summer migrant storks. Concentrations of 3000 storks are not uncommon each year. The efforts at St. Catherine's Creek included USFWS, USDA-NWRC and SREL personnel. Whereas, storks at Noxubee are relatively confined to small areas, the area at St. Catherine Creek encompasses thousands of acres of impounded water and finding the feeding site of storks is a daily hit-or-miss adventure. However, on Day 2, 10 storks were successfully captured under the net along with roseate spoonbills, white pelicans, egrets, herons, and white ibis. Four of the adult birds were fitted with transmitters and the remaining six were taken into captivity for feeding trials at Mississippi State University, USDA - National Wildlife Research Center.

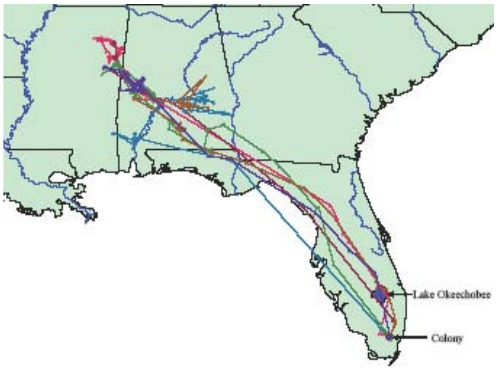


Wood Stork Private Lands Brochure Available

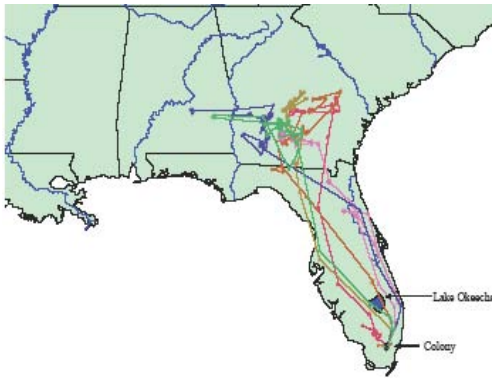
Through a contract with the SREL, Larry Bryan assisted the USFWS by developing a 12-page color brochure that addresses Wood Stork conservation and management for private landowners. The brochure can be printed from the following website: (*http://northflorida.fws.gov/WoodStorks/Documents/WOST-brochure.pdf*); or to receive color/glossy copy of this brochure, email your request to billy_brooks@fws.gov

...*Survival and Movements of Juvenile Wood Storks* continued from page 1

by ladder. The colony was visited on the ground from February through July 2003. After high levels of abandonment and chick death in the Tamiami West colony in 2003, we also briefly worked in the Martin County Spoil Island 2 (MC2) colony (N27 11.40, W80 11.27), located just south of Sewalls Point, FL. MC2 is a mixed-species wading bird colony with approximately 50 storks nesting in red mangrove (*Rhizophora mangle)* and sea grape (*Coccoloba uvifera)*. Although we conducted health exams and deployed satellite transmitters on 5 juvenile storks hatched in this colony , we did not monitor nesting success in this colony. We worked in this colony in late May 2003, only after all available juvenile storks in Tamiami West colony had died or fledged.



Migratory pathway of juvenile Everglades Wood Storks that summered in Alabama and Mississippi in 2002. Each color represents a different individual (n=5).



Migratory pathway of juvenile Everglades Wood Storks that summered in Georgia in 2002. Each color represents a different individual (n=6).

Reproductive Success

Approximately 350 Wood Stork nests were initiated in Tamiami West in 2003, but heavy rain events in February and March were probably responsible for the roughly 50% abandonment rate seen in this colony. A total of 108 nests were marked with numbered surveyors flagging to determine rates of survival. We conducted nest checks every 4-7 days throughout the nesting season to determine nest contents and age of nestlings. At the initial time of marking in early March, 96% of the 84 nests marked were still being incubated. The average clutch size of marked nests located during incubation monitored during the period when nestlings were 8-14 days old was 2.97 (SE=0.15, n=38).

Overall traditional nesting success (number of nests fledging at least one young /number of nests studied) for this colony was 24.07% (26/108 nests). This success rate was 31% lower than in 2002 (77.39% 89/115 nests). Of 82 nests that failed during 2003, 73.17% failures occurred early in the nesting season, during March. We also used Mayfield's method of analyzing nesting success, which pro-rates survival on a daily basis. During the incubation stage, Mayfield survival was 19.04% (SE=0.57). This was 61% lower than in 2002 (49.66% SE=1.02). Although Mayfield success during the nestling period in 2002 was quite high at 89.29% (SE=1.63) in 2002, nestling survival during 2003 was only 23.28% (SE=0.76). The overall, combined Mayfield nesting success for these 2 periods was 44.34% (SE=0.624) in 2002, and 4.43% (SE=0.17) in 2003.

Nestling Health

After the 2003 nestlings reached 4-6 weeks of age, first hatched nestlings from 34 nests from Tamiami West and 5 nests from MC2 were randomly selected for inclusion in our health and telemetry studies. After a juvenile stork was captured on the nest, we performed a health exam on each individual. Skeletal measurements (culmen and tarsus) and mass were recorded which will be used to develop an index of body condition. Each health exam included a physical examination for ectoparasites, palpation for Eustrongylides nematodes, and collection of up to 2 ml of blood. Blood was used for sexing, hematocrit, white blood cell counts, and blood smears which will later be examined for the presence of blood parasites. In addition, 4 – 6 growing scapular feathers were collected from each bird to determine level of mercury contamination. This information will be used to construct an estimation of the health, parasite load, and body condition of each bird.

Satellite Telemetry – Juvenile Survival and Movement Patterns

Following the health exam, each bird was fitted with a backpack harness that combined a 10g VHF radio transmitter and a 35g solar-powered ARGOS certified platform transmitter terminals (PTT) for satellite tracking. The total weight of the Teflon harness, VHF transmitter and PTT did not exceed 3% of the Wood Stork's fledging mass (2 – 2.8 kg).

Signals from the PTTs are recorded by polar-orbiting environmental satellites and then processed by Argos Satellite Location and Data Collection System, Landover, MD. PTTs work on a 10 hr on/24 hr off cycle. Argos assigns each location an accuracy rating, and only locations with estimated accuracies of <1000m are being used in this study. These data will be used to follow their post-fledging survival and to examine their movement patterns and habitat use in years to come.

Of the 39 nestling storks tagged in 2003, 17 died in the Tamiami West colony and 2 died in the MC2 colony before fledging. The 3 remaining live birds in MC2 had not fledged as of late June. Of the remaining 17 tagged birds that fledged from Tamiami West, satellite data suggests that 7 have died as of 25 June 2003 (41.18%). These tagged fledglings are believed to have all died in central and south Florida. Of those 26 mortalities, we have recovered 13 transmitters; relocations of the remaining 13 transmitters are ongoing.

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...***Survival and Movements of Juvenile Wood Storks*** *continued from page* 3

Juvenile stork movement patterns in 2003 were similar to patterns recorded in 2002. After fledging, juveniles generally moved north through the Water Conservation Areas and Big Cypress National Preserve. Following this initial local movement, the majority of storks continued moving north. As of 1 Jul 2003, 3 of the newly fledged 2003 birds were in Georgia, while the rest were spread across central and north Florida. Of the 12 surviving 2002 birds, 2 are in Georgia, 1 is in Alabama, and the remainder are in Florida. We anticipate many more of these birds to leave Florida in the upcoming months for Mississippi, Alabama, South Carolina, and Georgia, as this pattern was observed in 2002.

Movement Patterns of Birds Tagged in 2002

In south Florida, birds monitored by radio telemetry were seen foraging individually as well as in large mixed groups containing both adults and other juveniles. In the past 6 months however, we have very few indications that any of the tagged fledged storks have been traveling together. This is quite interesting considering many young were tagged from adjacent nests in the same colony and therefore had plenty of chance to develop social groupings based on natal colony . Many of these birds have also frequently visited the same areas throughout the southeastern United States, although not simultaneously. After tagged storks left the colony in a permanent way , in general they moved north through the Water Conservation Areas and Big Cypress National Preserve.

After this initial local movement, the majority (16 of 27) of storks continued moving north, spreading across the coastal plains of Florida, Georgia, South Carolina, Alabama, and Mississippi (Figure 1). The birds that left Florida did so in a roughly simultaneous way during the second week of June, and tagged birds were found in Alabama, Georgia, and South Carolina. Of 16 birds to leave Florida, 11 moved through Georgia, 8 through Alabama, 3 through South Carolina, and 1 briefly crossed the border into North Carolina. To date, a total of 5 birds have moved through Alabama into Mississippi, with the first bird having arrived the last week of June. Fifteen of these 16 birds set up primary summer "home ranges" outside of Florida: 2 in South Carolina, 7 in Georgia, and 6 in Alabama/Mississippi. The simultaneous departure **of** 3 birds from Mississippi into Alabama and Florida and one Alabama bird into Florida during the last week of September coincided with the arrival of tropical storm Isidore that made landfall directly over New Orleans, LA. The rains and strong winds from this storm may have been an impetus for withdrawal from these areas.

We identified multiple northern movement pathways for these juvenile birds. Three birds left south Florida and flew north through the western-central portion of peninsular Florida, turning northwest into Alabama once they reached the Florida panhandle (Figure 2). Two other birds also arrived at the same destination, but followed a coastal path through Florida along the Gulf of Mexico before making their way into Alabama. All 5 birds remained in Alabama or moved into northeast Mississippi for the remainder of the summer. These birds were most frequently located along the Tennessee-Tombigbee Waterway in Alabama and Mississippi.

There were an additional 6 birds that spent the majority of their summer (Jun – Sep) in Georgia. Of these, 2 traveled north along the Gulf Coast of Florida, 2 along the Atlantic Coast, and 2 directly through the center of peninsular Florida after leaving the colony located just west of Miami (Figure 3).

A large portion of tagged birds, 11 of 26, remained in Florida after fledging from the colony (Figure 4). Most of these birds summered around the edges of Lake Okeechobee or headed further west along the Gulf Coast. These western birds tended to be localized between Tampa and Fort Myers. In this area, the C.M. Webb Wildlife Management Area, just southwest of Port Charlotte, was frequented most often. By the beginning of November, all northern birds located outside of Florida moved back south into central and south Florida. The areas around Lake Okeechobee and along the Gulf Coast appeared to be important wintering areas for many of these young birds.

Recovery Partners

USFWS - US Fish and Wildlife Service
FWC - Florida Fish and Wildlife Conservation Commission
GDNR - Georgia Department of Natural Resources
SCDNR - South Carolina Department of Natural Resources
SREL - Savannah River Ecology Laboratory
UF - University of Florida
ENP - Everglades National Park
BCP - Big Cypress Preserve
SWA - Palm Beach County Solid Waste Authority
FDEP - Florida Department of Environmental Protection State Parks and Preserves
Pumpkin Hill Preserve and Faver Dykes State Park
USGS - US Geological Survey-National Wetlands Research Center
USDA - US Department of Agriculture - National Wildlife Research Center
SFWMD - South Florida Water Management District
SWFWMD - Southwest Florida Water Management District
SJRWMD - St. Johns River Water Management District
FPL - Florida Power and Light
Jacksonville Zoological Gardens
Audubon of Florida Coastal Islands Sanctuaries
Audubon of Florida Corkscrew Swamp Sanctuary
Audubon of Florida Duval/St. Johns/Martin/Pasco County Chapters
ARCI - Avian Research and Conservation Institute
DAK - Disney Animal Kingdom
SCIF - St. Catherines Island Foundation
St. Augustine Alligator Farm

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Wayne Lasch

Federal Classification Of Wood Storks

On February 28, 1984, the USFWS listed the United States breeding population of the Wood Stork (in Florida, Georgia, South Carolina, and Alabama) as endangered under the Endangered Species Act of 1973, as amended (ESA). A recovery plan for this species was approved in 1986 and was revised in 1997. The ESA defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." A species can be listed or delisted if the Secretary of the Interior determines that the species no longer meets the endangered or threatened status based upon these five factors listed in Section 4(a)(1) of the ESA:

(1) the present or threatened destruction, modification, or curtailment of its habitat or range;
(2) overutilization for commercial, recreational, scientific, or educational purposes;
(3) disease or predation;
(4) the inadequacy of existing regulatory mechanisms; and
(5) other natural or manmade factors affecting its continued existence.

Measuring The Biological Recovery Of Wood Storks

Measuring the biological aspect of the recovery of the Wood Stork is outlined in the USFWS 1997 Wood Stork Recovery Plan. The plan's recovery criteria state that reclassification from endangered to threatened could be considered when there are 6,000 nesting pairs and annual regional productivity is greater than 1.5 chicks per nest/year (calculated over a 3-year average). Delisting could be considered when there are 10,000 nesting pairs calculated over a 5-year period beginning at the time of reclassification and annual regional productivity is greater than 1.5 chicks per nest/year (calculated over a 5-year average). As a subset of the 10,000 nesting pairs, a minimum of 2,500 nesting pairs must occur in the Everglades and Big Cypress systems in south Florida. The number of nesting pairs is ascertained through aerial surveys supported and flown by the USFWS, SCDNR, GDNR and FWC. The Productivity Monitoring Initiative began with the drafting of a scientific protocol (see the 2002 Wood Stork Report). The first year of data collection began at several regional index colonies and preliminary results are found later in this newsletter. The number of colonies that will be monitored in year two of this initiative has increased to more than 20 colonies throughout the breeding range. Aerial surveys to count nests is entering the fourth year of data collection.

Wood Stork Websites

U.S. Fish and Wildlife Service
https://ecos.fws.gov/species_profile/SpeciesProfile?spcode=B06O
U.S. Fish and Wildlife Service Jacksonville Field Office
http://northflorida.fws.gov/WoodStorks/wood-storks.htm
U.S. Fish and Wildlife Service South Florida Field Office (Vero Beach)
http://verobeach.fws.gov/species/birds/wost/wost-guide.htm
Everglades National Park
http://www.nps.gov/ever/eco/wdstork.htm
South Florida Water Management District (South Florida Wading Bird Report)
http://www.sfwmd.gov/org/wrp/wrp_evg/projects/wading01
University of Florida
http://www.wec.ufl.edu/faculty/FrederickP/stork/index.htm
University of Georgia Savannah River Ecology Laboratory
http://www.uga.edu/srel/Fact_Sheets/wood_storks.htm
Wildlife Trust
http://www.wesave.org/stork/
http://www.wesave.org/oldstork/
Corkscrew Swamp Sanctuary (Florida Audubon)
http://www.audubon.org/local/sanctuary/corkscrew/
FPL (Florida Power and Light)
http://www.fpl.com/environment/endangered/contents/wood_storks_overview.shtml

Synoptic Aerial Surveys

The USFWS acknowledges the limitations involved in relying on aerial surveys for developing population estimates. However , storks are a long lived species that demonstrate considerable variation in population numbers in response to changing hydrological conditions. Over the long term, aerial surveys are the most cost effective method for estimating population trends. Ground surveys, while providing greater individual colony accuracy, are more time consuming and expensive on a regionwide basis. Replication of surveys and ground counts at selected index colonies will help to minimize variability and will also provide information regarding the second component of the recovery criteria, productivity (chicks per nest).

A series of aerial surveys to locate all Wood Stork nesting colonies was first flown in 1957. This effort was reinitiated in 1975 and flown for 10 years by the Audubon Society and other partners. These surveys were flown by **John Ogden** (*jogden@sfwmd.gov*) and others. In 1991, the USFWS reinitiated this synoptic effort again to monitor the nesting pair aspect of the Wood Stork recovery criteria, and partnered with the SCDNR, GDNR, The Audubon Society, and FWC to fly surveys from 1991 to 1995. In 2001, the USFWS reinitiated another 5-year synoptic aerial survey effort. Based upon the surveys and information from monitoring at individual colonies, it is estimated that there were an estimated 9,291-9,416 nest starts by Wood Storks at 78 active colonies in FL, GA, and SC in 2003. This compares to 9,016-10,126 at 71 colonies in 2002 and 4,998 at 43 colonies in 2001.

It should be noted that the reported number of nest starts are usually "peak" counts, in which the highest count for the season is used as the estimate of nests. Also, it should be noted that the synoptic numbers presented will be under further review and are likely to change. Finally, there was a synoptic aerial survey flown in 1999 as the GDNR and SCDNR flew their annual Wood Stork surveys and the FWC conducted surveys to update the "Florida Atlas of Breeding Sites for Herons and Their Allies." The FWC survey methodology for this survey (**see Accuracy of Aerial Surveys of Waterbird Colonies in Florida** later in this newsletter) does not allow for direct comparison of nest numbers, However this survey does suggest a very large nesting effort by Wood Storks in FL in 1999. With 42 active colonies and a minimum range value of 7,000 nesting pairs in FL and with 21 active colonies in GA and SC with 1,658 nesting pairs Wood Stork nests, the 1999 total nesting effort at 63 colonies approached 9,000 nest starts.

Wood Stork Recovery Plan Available (1997) at:
http://northflorida.fws.gov/WoodStorks/wood-storks.htm.
Wood Stork section of the **South Florida Multi-Species Recovery Plan (2001)** at:
http://verobeach.fws.gov/Programs/Recovery/vbms5.html


Sewel Point, Martin County, Florida

Pilot Study: Transect Surveys of Potential Nesting Habitat in FL
Ken Meyer (ARCI) (meyer@arcinst.org) and PeterFrederick (UF) (pcf@mail.ifas.ufl.edu).

We pointed out in our Florida Survey of Wood Stork Nesting Colonies, 2002 Final Report to USFWS that considerable underestimates of the number of Wood Stork nests can result from shifts in colony locations between years. To determine whether aerial surveys could be used to discover previously unobserved nesting colonies, we flew three rectangular search patterns in central Florida from 28 May to 11 June 2003. The plots were positioned to include as much suitable nesting habitat as possible. Each plot was 50 km long (aligned east/west) and 21 km wide. We flew seven parallel transects spaced 3.0 km (1.85 statute miles, 1.60 nautical miles) apart at an altitude of 300 m above ground level and an airspeed of about 160 km/h. Plot A straddled the Pasco/

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Wood Stork Research and Monitoring Working Group

The annual meeting of the Research and Monitoring Working Group was hosted by St. Catherines Island Foundation at their Endangered Species Breeding Facility on St. Catherines Island, Georgia on October 22-24, 2003. We are very greatful to the St. Catherines Island Foundation and the Larkin Family for providing us with a meeting location. The meeting was well attended, and much of the information presented at the meeting is found within this newsletter. The USFWS is very appreciative of the efforts that were made to attend the meeting and to share information regarding Wood Stork recovery. Many thanks to Jenifer Hilburn and Royce Hayes and the staff of the St. Catherines Island Foundation for hosting the meeting and for providing us with the informative tours of St. Catherines Island and the Breeding Facility. And many thanks to Brad Winn of the Georgia DNR for logistical assistance, help in planning the meeting, for planning meals, doing all the shopping, and as our master chef!!!

...Synoptic Aerial Surveys continued from page 6

Hillsborough County line and included the northeastern corner of Pinellas County. Plot B centered roughly on Blue Cypress Lake and consisted mostly of Indian River County with parts of Brevard, Osceola, and Okeechobee counties. Plot C included parts of Hillsborough and Polk counties (south of Lakeland). The three transect surveys were flown on separate days between the hours of 08:30 and 18:00. Two observers seated on opposite sides of the airplane directed their continuous scan 90 degrees to the transect for a distance of 1.5 km from the transect (halfway to the adjacent transect). We diverted from the transect to inspect any white birds seen on the ground within that distance (and used GPS fixes to resume course along the transect after each diversion). If nesting Wood Storks were present, we circled the colony to count and v ideo-tape the nests as we did during the regular FL colony counts. If complete visual coverage is assumed, we searched a total of 3,150 sq km (1,050 sq km per plot). It was unlikely, however, that Wood Storks were uniformly detectable over the entire 1.5 km lateral distance on either side of each transect.

SC, GA, and FL Wood Stork Nests from aerial synoptic survey data.

Year	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total Nests	5,110	5,275	2,520	4,984	4,827	4,146	3,990	6,075	6,040	5,215
#of Colonies	17	24	16	23	23	23	22	26	29	26
Year	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Total Nests	5,835					4,073		6,729	5,523	7,853
#of Colonies	36					37		43	47	56
Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Total Nests				>9,000		5,131	9,016-10,126	9,291-9,416		
#of Colonies				63		44	71	78		

As Rodgers et al. (1995) warned, estimates of Wood Stork nesting effort based on aerial surveys can have very large confidence intervals. Most of this variability results from the cumulative errors associated with counts of large, mixed-species colonies with high proportions of other white-plumage species; the general error is to confuse Wood Storks with Great Egrets, usually resulting in an over-estimate of storks. The USFWS (1996) has taken the position, however, that aerial surveys are the most cost-effective long-term method for estimating Wood Stork population trends.

In our 2002 report, we pointed out that considerable underestimates can result from shifts in colony locations between years if the birds move far enough to evade detection under the present search protocol, which focuses only, and rather narrowly, on previously used sites. The results of our aerial transect surveys support this contention. We found three colonies on the plot flown th e earliest. The flights on the other two plots were delayed nearly two weeks (until mid-June) by cancellations due to poor weather conditions (five flights were cancelled over the course of completing our eight colony-count and transect surveys). Our effective visual coverage, furthermore, was only about two-thirds of the area within each plot. If funding would permit coverage of more transect plots and more closely spaced transects, and if the surveys could be flown earlier in the season, it is likely that more previously undetected colonies would be found.

We also believe that there is likely to be considerable underestimation as a result of counting each colony at only a single point in time, because nests that fail earlier or start later than the survey date will not be counted. Modeling suggests that this could r esult in undercounts of 20–50% in the case of birds with a long nesting season and asynchronous nesting, such as Wood Storks. We suggest that effort should be devoted to finding affordable ways to improve the accuracy of our statewide estimates of Wood Stork nesting effort.

People on the Move

Rich Paul accepted an early retirement fromAudubon, effective Dec. 26. He is looking forward to new adventures and time to do more writing. His new email is richpaul26@earthlink.com. I know we will hear more from Rich, and hopefully some of his adventures will include Wood Storks.

On the move **is Dr. Dale E. Gawlik**. After many years at the South Florida Water Management District conducting research on topics such as wading bird feeding ecology and editing the South Florida Wading Bird Report, Dale has joined the faculty at FloridaAtlantic University Department of Biological Sciences. We look forward to seeing more good science from Dale and hopefully many graduate students. Dale's new email address is: dgawlik@fau.edu

Rena Borkhatarai is beginning her doctoral work at University of Florida on movements and survival ofWood Storks. She takes over the satellite telemetry work that **Becky Hylton** started, and is already working in south Florida. Rena received a bachelor's degree from Arizona State University, and a sters degree from University of North Carolina. Her masters work was on the effects of Puerto Rican shade-grown coffee on avian, reptile and insect communities.

Accuracy of Aerial Surveys of Waterbird Colonies in Florida

James A. Rodgers, Jr., Paul S. Kubilis, and Stephen A. Nesbitt (FWC)

There have been 3 statewide surveys of wading bird colonies in Florida during 1976-1978 (Nesbitt et al. 1982), 1986-1989 (Runde et al. 1991), and in 1999 (Nesbitt and Rodgers 2002). Each of these inventories used fixed-wing aircraft, which is a relatively inexpensive and rapid technique that allows coverage of large areas when compared to standard ground counts. Aerial surveys also provide estimates for sites not easily accessible to ground visits, such as difficult to reach colonies, sites with a large number or highly-dispersed nests, and sites in private ownership where access is denied.

However, the accuracy of aerial surveys may vary with observer, colony size, species composition, and canopy cover, especially with brief and rapid flights typical of fixed-wing aircraft (Kadlec and Drury 1968, Hutchinson 1979, Kushlan 1979, Rodgers et al. 1995). Aerial surveys for smaller, more cryptically-colored species that usually nest beneath the canopy would be expected to be even less reliable.

In conjunction with a statewide aerial survey of wading bird colonies in 1999, we conducted ground-truthing surveys in selected colonies to evaluate the efficacy of the aerial technique in Florida. Knowledge of the error in species detection associated with the aerial survey would permit evaluation of the biases for an individual colony and statewide distribution. We also examined the ability of an aerial survey to provide accurate estimates for the size of a colony and find previously unknown colonies. A final objective of our study was to develop recommendations for improving the accuracy of statewide surveys.

Methods

Aerial survey

The aerial survey of waterbird colonies in Florida occurred during April to July of 1999 and consisted of flying transects at 5 km intervals using a fixed-wing aircraft (e.g., Cessna 172 or 182). Previously known locations of waterbird colonies from Nesbitt et al. (1982) and Runde et al. (1991) were marked within 5-km wide corridors oriented from east to west on flight maps. The aerial flight path generally was made down the middle of these transect-bounded corridors, deviating to survey previously known nesting sites or follow flight lines of birds to locate previously unknown colonies. North-south linear routes also were flown along portions of the Atlantic and Gulf coasts as a check of detection rates of the regular east- west oriented transects in peninsular Florida.

Pre-survey training of observers consisted of both ground and in-flight identification of wading birds to improve the accuracy of species identification during the aerial survey. An aerial survey of a nesting site generally consisted of circling the colony several times at an altitude approximately 100-125 m to differentiate between the individual birds on their nests. Most of the south Florida colonies (# 28°N latitude) were surveyed during March-April while the north and central Florida colonies (> 28°N latitude) were flown during May-June in order to accommodate north-south differences in the peak of waterbird nesting activity (Rodgers and Schwikert 1997).

Ground surveys

We selected colonies for ground-truthing in north and central Florida based on access (both public, and with permission, private sites), area of coverage (small [< 1 ha], medium [1-2 ha], and large colonies [> 2 ha]), number of breeding birds (small [< 100 nests], medium [100-300 nests], and large [> 300 nests]), open versus closed canopy nesting, few versus numerous white-plumaged species, and few versus numerous dark-plumaged species. Colony locations were derived from the concurrent statewide aerial survey and colonies known to be active since the last survey during 1986-1989. These latter colonies were used to examine the aerial detection rate of previously unknown colonies.

Colonies were chosen because all nests were accessible for ground surveys. Our survey technique employed two observers slowly moving through the colony on foot or by boat either along transects or in a serpentine pattern. Waterbirds were identified with or without binoculars as necessary, and at sufficient distance to prevent flushing. We only counted birds on nests to assure positive identification of species of waterbirds that were actually breeding in the colony.

Data analysis

The primary goal of the ground surveying portion of the study was to evaluate the usefulness of aerial surveys (Air) as a method to detect species of waterbirds compared to ground surveys (Ground). A secondary objective was the examination of the ability of Air to locate previously unknown colonies. Components of the analysis were as follows.

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West of Lake City, Columbia Coutny, Florida

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Species detection by Air. There are four possible outcomes for the detection of a species during an Air survey compared to the presence or absence of the species during a Ground survey. True positive rate (also called sensitivity): both the Ground and Air surveys observed a species nesting. False negative rate (1 ! sensitivity): the Ground survey observed a species nesting but the Air survey failed to observe the species nesting. True negative rate (also called specificity): both the Ground and Air surveys did not observe the species nesting. False positive rate (1 ! specificity): the Ground survey did not observe a species nesting but the Air survey observed the species nesting.

Initially we selected 32 colonies surveyed by both Air and Ground for species of nesting waterbirds. However, we only examined a subset of 23 of these 32 colonies with a narrower range of time intervals between Air and Ground visits (0 difference = 15.45 days, SD = 10.6 days) to avoid bias in species detection. This difference between Air and Ground is well within the range of breeding chronology of species of waterbirds in Florida (Rodgers 1980, 1987; Rodgers and Schwikert 1997).


Midway Island, Lee County, Florida

Colony size classification by Air. Since Air colony size estimates were based on 6 colony nest-number size classes, Ground point estimates of colony size were converted to size class ranks and number of nests using the following categories: class 1 < 50 nests; class 2 = 50-250 nests; class 3 = 250-500 nests; class 4 = 500-1000 nests; class 5 = 1000-3000 nests; and class 6 > 3000 nests. The Wilcoxon rank sum test was used to compare the rank sums of Groun d colony size class estimates between groups of colonies defined by whether Air and Ground designations for presence or absence of a given species were in agreement or disagreement (Hollander and Wolfe 1973). All *P*-values reported are for two-tailed tests unless otherwise indicated.

Colony detection by Air. Air observers were instructed to visit all previously known colony sites and locate previously unreported colonies while flying the 5-km wide corridors. We Ground surveyed 45 colonies unreported by either Nesbitt et al. (1982) or Runde et al. (1991) that were active in 1999 to examine the detection rate of the Air survey.

Statistical analyses. All statistical calculations were carried out using SAS statistical procedures (SAS Institute, Inc. 2000). Exact binomial confidence intervals are provided for all binomial proportions or percentages reported (Leemis and Trivedi 1996), especially for sample sizes < 5. Receiver-operator characteristic analysis methods (Hanley and McNeil 1982) were used to assess the species detection performance of Air compared to Ground species detection. This included the calculation of Air true and false positive rates for each species. The nonparametric Wilcoxon signed rank test was used to detect bias in colony size class estimates generated by the Air and Ground surveys (Hollander and Wolfe 1973). The nonparametric Spearman rank correlation coefficient was used to assess the direction and strength of linear association between corresponding Air and Ground colony size class ranks (Hollander and Wolfe 1973).

The *c* statistic, also known as the probability of concordance (Hanley and McNeil 1982), was used to quantify the performance of Air versus Ground for species detection. The *c* statistic is independent of the prevalence of a species (i.e., the proportion of colonies with a species) because it takes into consideration both the sensitivity and specificity rates. The *c* statistic, asymptotic confidence intervals for *c*, and an asymptotic one-tailed z-statistic *P*-value for testing $c > 0.5$ versus $c \# 0.5$ were calculated using the FREQ procedure. The PROC procedure was first used to generate analogous statistics for the Somers' *D* statistic, which were converted appropriately using the relationship: $c = D / 2 + 0.5$ (Somers 1962, Hanley and McNeil 1982). The *c* statistic is a true probability that varies between 0 and 1 and simultaneously takes into account diagnostic performance as reflected by both the true and false positive rates. A *c* statistic value of 1 would indicate perfect Air species detection performance for both species presence and absence as compared to Ground. A *c* statistic value of 0.5 would indicate that Air detection ability was no better than would be expected if a random process (e.g., coin-flipping) were used to designate species presence or absence at a colony. A *c* statistic value of 0 would indicate a situation in which Air species detection performance was always incorrect compared to Ground for both species presence and absence.

Results

Ground data consisted of the presence or absence status for 16 species of waterbirds and point estimates of the overall number of nests for 23 colonies and the active status for 45 colonies in 1999.

Species detection by Air

Five nesting species (tricolored heron [*Egretta tricolor*], reddish egret [*E. rufescens*], black-crowned night-heron [*Nycticorax nycticorax*], yellow-crowned night-heron [*Nyctanassa violaceus*], and glossy ibis [*Plegadis falcinellus*]) observed by Ground were not detected at any of the 23 colonies by Air. Air true and false positive rates and exact

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Wayne Lasch

95% confidence intervals for detecting the presence of a species using ground assessments are listed in Tables 1 and 2. True positive rates were plotted against corresponding false positive rates for each species in Fig. 1. The one-tailed test *P*-values in Table 3 indicate that the *c* statistic was significantly greater ($P < 0.05$) than 0.5 for only 5 species. Air detection of a species was considered significantly better than would be expected if a random process were used to designate species' presence or absence for 5 large species: brown pelican (*Pelecanus occidentalis*, $c = 0.906$), double-crested cormorant (*Phalacrocorax auritus*, $c = 0.70$), anhinga (*Anhinga anhinga*, $c = 0.697$), cattle egret (*Bubulcus ibis*, $c = 0.731$), and Wood Stork (*Mycteria americana*, $c = 0.875$). However, Air exhibited a relatively low performance for the large great blue heron (*A. herodias*, $c = 0.604$), which was due to the low detection rate (30.8%). The detection of great egrets (*A. albus*, Tables 1 and 2) by Air was poor ($c = 0.481$) despite the species' relative large size and white plumage. Surprisingly, the one-tailed *P*-value for the dark-plumaged little blue heron [*E. caerulea*] was significant at the $P = 0.065$ level.

Species detection and colony size classification by Air

Using the Ground and Air detection results for each species, the 23 colonies were divided into two groups depending on whether Ground and Air designations of species presence or absence were in agreement or disagreement (Table 4). Colony size class was significantly (Wilcoxon rank sum test, $P < 0.05$) larger in colonies where Air and Ground results were in disagreement for 7 species (little blue heron, tricolored heron, reddish egret, yellow-crowned night-heron, white ibis [*Eudocimus albus*], glossy ibis, and roseate spoonbill [*Ajaia ajaja*]). Air false positive rates for these species ranged from 0.0% to 5.9%, whereas true positive rates were 50.0% for roseate spoonbill, 14.3% for little blue heron, and 0.0% for the remaining species. These rates and the fact that five of the species (tricolored heron, reddish egret, black-crowned night-heron, yellow-crowned night-heron, and glossy ibis) were not detected from the Air at any of the colonies suggest that disagreement was mainly caused by the inability of Air to detect these species when they were present in larger colonies. However, the colony size class rank sum was greater for colonies where Air and Ground results were in agreement for double-crested cormorant ($P = 0.059$). The Air false positive rate (Table 2) for this species was 33.3%, while the true positive rate (Table 1) was 72.7% ($c = 0.697$, $P = 0.020$).

Colony detection by Air

The Air colony detection rate for previously unknown colonies, defined as the proportion of active Ground colonies (n = 45) that were found to be active during the Air ($n = 32$) was 71.1% (exact 95th percentile confidence intervals: 55.7% and 83.6%). Thus, the probability of locating a previously unknown individual colony was between 56 and 84%.

Further examination of these 13 colonies did not provide a reason why they were missed by Air. These colonies were distributed among 5 counties and most contained multi-species (0 = 6.9, range = 1-10) and were intermediate in number of nests (0 = 594, range = 22-3,233).

Colony size classification by Air

Corresponding Air and Ground size class ranks were compared within-colony to assess the pattern and bias of Air errors in colony size class estimates relative to Ground estimates (Table 5). Mean ranks for the Air and Ground size class estimates were 3.30 and 2.96 respectively (median ranks were 4.0 and 2.0, respectively; $n = 23$ colonies). Ignoring Ground size class, errors in Air size class estimates were again somewhat symmetrically distributed in a bell shape about 0. The signed rank test again indicated no significant bias in Air size class estimation errors ($P = 0.257$). Air tended to overestimate size class in colonies with Ground size classes of < 50, 50-100, and 100-500 nests (7 out of the 7 errors were overestimates) and Air tended to underestimate size class in colonies with a Ground size class of 1000-3000 nests (3 out of the 3 errors were underestimates). There was a significant (Spearman $R = 0.519$, $P = 0.011$) positive correlation between Air and Ground size class ranks.

Discussion

Differences between aerial surveys using fixed-wing aircraft and ground surveys exhibit considerable variability on an individual colony and statewide basis (Rodgers et al. 1995, this study). As might be expected, larger species of waterbirds (e.g., brown pelican, Wood Stork) that typically nest on top of the colony vegetation are most visible and detectable during an aerial survey However, there was low detection of the intermediate-sized day herons (e.g., reddish egret, tricolored heron, glossy ibis) and both night-herons probably due to their characteristic nesting below the canopy and dark plumage. Unfortunately, many of these species are listed as Species of Special Concern by Florida and require more precise estimates of populations and trends for our conservation programs.

There also was a poor detection rate for great egrets, a relatively large (total length = 94-104 cm, mass = 812-935 g: McCrimmon et al. 2001), white-plumaged species that often nests high in the vegetation. However, we found great egrets also nest below the canopy and dispersed in low numbers that may make them difficult to detect from the Air. A

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contributing factor may have been confusion with other, more numerous species of white-plumaged wading birds, especially at colonies dominated by cattle egrets. Similar low detection of great blue herons may have been because the species tends to breed in low numbers with widely dispersed nests within a colony.

The high false positive rate for the double-crested cormorant may have been due to the inability of Air to distinguish between loafing and nesting birds as we observed during our Ground survey. Larger nesting colonies of cormorants were more accurately and easily detected by Air, whereas, smaller numbers of cormorants more often were non-nesting loafing birds.

North Fork St. Lucie River, St. Lucie County, Florida

Our analysis indicates an aerial survey would be most accurate in detecting larger species of waterbirds. Aerial photography with image-processing techniques also are capable of reliable counts of large species of birds (Laliberte and Ripple 2003). Since most waterbirds nest in mixed species colonies, an aerial survey can be initially used to locate breeding sites prior to ground surveys that would determine the actual species composition of the colonies. Ground surveys would be more appropriate and accurate to determine the overall species composition and particularly the nesting status of smaller species of waterbirds. A ground survey would be especially appropriate for smaller areas of coverage considering the increased effort involved with ground surveys. However, ground surveys have inherent problems in detecting some targeted species (Beier and Cunningham 1996, Jodice et al. 2001). Intensive ground surveys of colonial waterbirds also can result in disturbance.

Management implications

The low detection of the intermediate-sized day herons and both night-heron species probably was due to their characteristic nesting below the canopy and dark plumage. We also suspect the high false positive rate for the double-crested cormorants and great egrets may be due to the inability of observers to differentiate between nesting and loafing birds during the brief over-flights of colonies. Ground surveys would be required to determine the nesting status of these species of waterbirds. Kadlec and Drury (1968) concluded that aerial estimates could not reliably detect < 25% change in herring gull (*Larus argentatus*) populations; thus, the estimates of gull numbers were adequate only to determine general population levels and cumulative trends over a 4-5 year interval. A single aerial survey of an individual colony may provide information only on the status of a colony (i.e., if the colony is active and an index value for trend analysis) or a relative population estimate (Rodgers et al. 1995).

Jodice et al. (2001) concluded that even moderate levels of variability in survey data may require substantial sampling effort to overcome the low performance of most inventory methods, and the reliability of survey data must be assessed prior to initiating long-term monitoring plans. We suggest that the level of variability and probability of species detection should be assessed prior to conducting large-scale inventories for colonial waterbirds. Surveying Florida (area = 151,671 km^2) during 1999 required 30,140 km of transects spaced at 5 km widths for a total of $95,321, of which $38,561 was for aircraft rental. The estimated colony detection rate of 55.7–83.6% based on 5 km wide corridors suggests that smaller width corridors may be required during an Air survey. However, our alternative design of 2.5 km wide corridors requiring over 60,000 km of transects to cover Florida proved to be too time consuming and costly to be accomplished during the breeding season. Smaller corridors would be appropriate when surveying colonies with few nests and nests dispersed over a small area, smaller coverage areas where more accurate data are required (e.g., inventories prior to construction and development), or in regions known to have higher densities of nesting colonies such as coastal sites and everglades of Florida.

Both the sensitivity (true positive rate) and specificity (true negative rate) need to be considered in evaluating detection performance of a survey. An ideal survey would have the both the highest sensitivity and specificity rates as possible. However, certain situations might call for sacrificing one quantity in order to optimize the other parameter. A low sensitivity rate results in under estimates (i.e., false negative detections decrease the observed rate of the species lower than actual occurrence) while a low specificity results in an over estimate (i.e., false positive detections inflate the observed rate of the species higher than actual occurrence) of the population. The management implication of a high false negative rate is an under estimate for the species' presence in an Air survey. The management implication of a high false positive rate is an over estimate for the species' presence in an Air survey. When surveying a large area and number of colonies for a large species that is highly visible, a biologist could use the quick and relatively inexpensive fixed-winged aircraft for brown pelicans with a high sensitivity rate (Table 1) but only moderate false positive rate (Table 2). When there are dire consequences of a rare or endangered species going undetected and the area is relatively small, a researcher should use a survey method that has high sensitivity and specificity rates. A high proportion of the targeted species would be correctly

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detected in a ground survey with a relatively low probability of over estimating the species' occurrence.

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Literature Cited

Beier, P. and S. C. Cunningham. 1996. Power of track surveys to detect changes in cougar populations. Wildlife Society Bulletin 24:540-546.

Hanley, J. A., and B. J. McNeil. 1982. The meaning and use of the area under a receiver-operator characteristic (ROC) curve. Radiology 143:29-36.

Hollander, M., and D.A. Wolfe. 1973. Nonparametric Statistical Methods. John Wiley and Sons, Incorporated, New York, New York, USA.

Hutchinson, A. E. 1979. Estimating numbers of colonial nesting seabirds: a comparison of techniques. Proceedings of the Colonial Waterbird Group 3:235-244.

Jodice, P. G. R., S. L. Garman, and M. W. Collopy. 2001. Using resampling to assess reliability of audio-visual survey strategies for Marbled Murrelets at inland forested sites. Waterbirds 24:331-344.

Kadlec, J. A., and W. H. Drury. 1968. Aerial estimation of the size of gull breeding colonies. Journal of Wildlife Management 32:287-293.

Kushlan, J. A. 1979. Effects of helicopter censuses on wading bird colonies. Journal of Wildlife Management 43:756-760.

Laliberte, A. S., and W. J. Ripple. 2003. Automated wildlife counts from remotely sensed imagery. Wildlife Society Bulletin 31:362-371.

Leemis, L. M., and K. S. Trivedi. 1996. A comparison of approximate interval estimators for the Bernoulli parameter American Statistician 50:63-68.

Nesbitt, S. A., J. C. Ogden, H.W. Kale, II, B.W. Patty, and L.A. Rowse. 1982. Florida atlas of breeding sites for herons and their allies: 1976-78. FWS/OBS-81-49. Office Biological Services, U.S. Fish and Wildlife Service, Washington, District of Columbia, USA.

Nesbitt, S. A., and J. A. Rodgers, Jr. 2002. Atlas of waterbird colonies in Florida during 1999, with an analysis of the accuracy of aerial estimates. Final report number 7613. Bureau of Wildlife Diversity Conservation, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Rodgers, J. A., Jr. 1980. Breeding ecology of the little blue heron on the west coast of Florida. Condor 82:164-169.

Rodgers, J. A., Jr. 1987. Breeding chronology and reproductive success of cattle egrets and little blue herons on the west coast of Florida, USA. Colonial Waterbirds 10:38-44.

Rodgers, J. A., Jr., S. B. Linda, and S. A. Nesbitt. 1995. Comparing aerial estimates with ground counts of nests in Wood Stork colonies. Journal of Wildlife Management 59:656-666.

Rodgers, Jr., J. A., and S. T. Schwikert. 1997. Breeding success and chronology of Wood Storks *Mycteria americana* in northern and central Florida, U.S.A. Ibis 139:76-91.

Runde, D. E., J.A. Gore, J.A. Hovis, M. S. Robson, and PD. Southall. 1991. Florida atlas of breeding sites for herons and their allies–update 1986-89. Nongame Wildlife Progress Technical Report no. 10. Florida Game and Fresh Water Commission, Tallahassee, Florida, USA.

SAS Institute Inc. 2000. The SAS system, release 8 for Windows. SAS Institute, Cary, North Carolina, USA.

Somers, R. H. 1962. A new asymmetric measure of association for ordinal variables. American Sociological Review 27:799-811.

Banding at Selected Georgia Colonies Continues

Larry Bryan (SREL)

SREL has continued a leg-banding project that began back in the 1980s at the Big Dukes Pond/Birdsville Colony in GA. Over the past several years Larry and John Robinette of the USFWS have banded between 70 and 90 chicks at the Woody Pond Colony at the Harris Neck NWR. Larry and other SREL staffers have also banded between 25-45 chicks at Chew Mill Pond Colony and 20-23 at St. Simons Island Colony, annually. Close to 1,000 Wood Stork chicks have been banded at these GA colonies since 1995. Re-sightings typically come from coastal GA and SC. There have also been sightings of these birds in MS, AL, and down into FL. This year's banded stork sightings came from Big Cypress National Preserve (FL) - 2, Tampa, (FL) - 2, Jacksonville (FL) Zoo - 2, and the National Audubon Society's Kathwood foraging ponds (SC) - 1.

Larry and Donna Bear-Hull of the Jacksonville Zoological Gardens initiated a chick banding project at the Zoo. They were able to band 15 chicks from 5 nests. An additional 10 chicks, which fell out of the nests were rehabilitated by the Zoo Veterinarian and Keeper staff were banded and soft released into a holding pen near the nesting trees.

The Wood Storks are banded with a USGS band on the left leg and a colored numbered band on the right leg. Yellow bands with black lettering are from the St. Simons Island (GA) Colony; orange bands with black lettering are from the Chew Mill Pond Colony; red bands with white lettering are from the Woody Pond Colony at Harris Neck NWR; and light blue bands with black lettering are from the Jacksonville Zoo.

Wood stork with satellite transmitter backpack.

Across The Southeast...

SOUTH CAROLINA

Annual surveys have been conducted in SC since the first successful stork nesting was documented with 11 nests in 1981. This effort and extensive database is important in quantifying the rate of recruitment to the state and to determining the status of Wood Stork recovery in the southeast U.S. **Tom Murphy** (*murphyt@scdnr.state.sc.us*) with **SCDNR Division of Wildlife and Freshwater Fisheries** reports that their aerial and ground surveys documented 1,356 nest starts at 11 colonies in 2003, up from 1,136 at 10 sites in 2002. Colonies ranged in size from 44 nesting pairs to the largest colony with 385. SC's drought came to an end during 2003 but the two colony sites that were active in 2001 but not 2002 because the sites were dry, had water under the trees but no Wood Stork nesting in 2003. For the 7 colonies surveyed for productivity, estimated productivity was 2.20 per successful nest. New in 2003, Tom undertook a study to assess Wood Stork egg incubation temperatures using "temperature dataloggers". Dataloggers were placed in wooden eggs with the temperature sensor on the surface. These eggs were placed under incubating storks and recorded an egg temperature every 30 seconds. These temperatures were compared to ambient air temperatures to document normal incubation behavior. Tom reports that Wood Stork nests that they monitored maintain their egg temperatures between 33-35 C. As most colony sites in SC are in manmade ponds, land managers have played a critical role in maintaining water levels at Wood Stork colonies. For information regarding specific Wood Stork colonies in SC, you should contact Tom Murphy directly.

Charles Bear

GEORGIA

The GDNR maintains a Wood Stork database on rookery locations, number of nesting pairs, and when available productivity of Wood Storks in GA. This database dates back to 1980 and is extremely valuable in monitoring Wood Stork recovery. **Brad Winn** (*brad_winn@dnr.state.ga.us*) of the **GDNR Non-Game Endangered Wildlife Program** reports that GA drought conditions came to an end during 2003. Helicopter surveys of 70 wading bird rookeries including 28 that have been used historically by Wood Storks, were flown on May 5-7, 2003. Additionally, Larry Bryan monitored the Big Dukes and Chew Millpond rookeries and John Robinette monitored the Harris Neck NWR colony (details of these efforts are found in the following paragraphs). There were 18 active Wood Stork colonies in GA during the 2003 breeding season, up from 14 in 2002. Two known wading bird rookeries were used by Wood Storks for the first time this season, and one site not known to support wading birds was confirmed to have nesting storks, for a total of three new nesting locations in 2003. There were an estimated 1,601 nesting pairs of Wood Storks in 2003, as compared to 1,258 in 2002. Fourteen of the 18 (78%) active Wood Stork colonies in GA in 2003 were located on private land. Two colonies (11%) were on state properties, and two (11%) were on federal property including the largest colony at Harris Neck NWR. Brad notes that most of the landowners are interested in protecting rookeries, however, acquisition of additional sites into public ownership would increase the security of Wood Storks in Georgia.

A 2002 GDNR pilot study to evaluate estimating productivity with aerial photography documented 1.8 (+/-.61) chicks per nest (n=66) from two southwest GA colonies. There was merit to the study protocol and in 2003, this effort was expanded to include several more colonies. The results are currently being analyzed.

John Robinette (*john_robinette@fws.gov*) of the **USFWS Harris Neck National Wildlife Refuge**, reports that there were a record 431 nest starts at this colony in 2003. He intensively monitored 60 individual nests (3 days per week) from an observation tower located on the outside edge of the colony. This monitoring documented that 48 of the 60 nests (80%) successfully fledged chicks. John estimates that 1.98 chicks fledged per nest start and 2.48 per successful nest. These data suggest that this colony fledged over 850 Wood Storks in 2003. The increase in productivity of successful nests at this colony correlates to the Refuge's feeding pond program where a series of ponds are stocked with and drawn down to concentrate the fish at different times during the breeding season. The record nesting effort at the Harris Neck NWR colony during the past several years is attributed to the refuge staff's ability to keep water in the impounded pond, even during times of drought. John notes that a majority of the 150 nesting platforms are being used predominantly by Wood Storks with one to as many as four nests per platform. John also notes that the cypress trees planted on the islands created in 1994 are large enough to support not only Wood Stork nesting on the tops of the trees but many other wading bird species on the lower branches. No significant storm events were identified to have impacted the breeding success in 2003.

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Across The Southeast...

Larry Bryan (*bryan@srel.edu*) of the **SREL** reports that the Big Dukes Pond (also known as Birdsville), which was dry and not active last year, had 87 nests in 2003. Thirty-two nests were monitored at this location. Eight nests failed and two were dropped from monitoring because of lack of visibility. Mean number of young fledged from all nests (n=30) was 1.4 (±1.0 SD) and from successful nests (n=21) was 2.0 (±.5 SD). The Chew Mill Pond Colony had an estimated 135 nests. Of the fifty-seven nests that were followed through the season, 24 failed. The mean number of young fledged from all nests (n=57) was 1.0 (±1.0 SD) and from successful nests (n=33) was 1.7 (± 0.5 SD). Whereas the rainfall assisted with the re-filling of the colony sites in 2003, above average rainfall continued through the breeding season and likely resulted in poor foraging conditions, water levels in foraging sites rising instead of the typical summer draw down.

For specific information regarding other Wood Stork colonies in GA, you should contact **Brad Winn** of the **GDNR** (*brad.winn@gadnr.state.ga.us)*.

FLORIDA

Billy Brooks (*billy_brooks@fws.gov*) of the **USFWS Endangered Species Recovery Program**, contracted with **Ken Meyer** (*meyer@arcinst.org*) of **ARCI** to survey a significant number of the Florida Wood Stork colonies known to be active during the past decade. The Everglades National Park, Everglades Water Conservation Areas 2 and 3, Big Cypress Preserve, Corkscrew Sanctuary are examples of colonies that have ongoing monitoring projects and where not flown by ARCI. During May 2003, ARCI conducted 5 survey flights and flew 62 of the FL colony locations. The results of these surveys and monitoring at individual colonies are included in the state wide totals reported below. Descriptions of monitoring at individual colonies are described later in this section of the newsletter.

The 73 locations surveyed for Wood Stork nesting activity in FL in 2003, by ARCI and other recovery partners, contained an estimated (6,334-6,459) nesting pairs of woods storks distributed among 49 active colonies in peninsular FL. This compares to (6,622-7,732) nest starts at 47 active colonies in 2002 and 2,022 nest starts at 22 colonies in 2001 (as the drought continued in the southeast U.S.). Of the 47 colonies that were active in 2002, 38 (78%) were active in 2003. The other 11 colonies active in 2003 consisted of five that had nests at some point between 1991 and 2001 and six that were surveyed for the first time in 2003. Additional information regarding many of the FL colonies can be found below.

Observations from all the monitoring efforts document that although nest initiations in south FL in 2003 were high, increasing rainfall and surface water beginning in March apparently caused abandonment of a large portion of the active nests in this region of FL. In contrast, surface water levels in central and northern FL were already high when nesting was initiated. Gradual increases through the season in those areas appeared to reduce nesting success, but the large-scale abandonments seen in south Florida did not occur in the north. Overall, the number of pairs that initiated nesting in FL in 2003 was not substantially smaller than the nuber nesting in 2002. The large-scale nest failures in south Florida, however, undoubtedly resulted in disproportionately lower productivity in 2003.

NORTH AND CENTRAL FLORIDA

Jim Rodgers (*jim.rodgers@fwc.state.fl.us*) of the **FWC** drafted the Productivity Monitoring Initiative Protocols (see the 2002 Wood Stork Report). Through funding from the FWC and the USFWS, Jim monitored productivity at several North and Central Florida Wood Stork colonies: Cypress Creek, New Port Richey, Lake Russell, Little Gator Creek, Lake Rosalie, Dee Dot, Lone Palm, Okhlockonee, Croom and Chaires. These had an estimated 1,979-2,129 nest starts of which Jim and other FWC staff monitored 1,627 nests. He also assisted other biologists who volunteered to monitor additional colonies. Jim compiled and analyzed this tremendous monitoring effort and the results are found later in the newsletter in **Productivity of Wood Storks in North and Central Florida**. Information from individual colonies and conservation efforts at those sites are reported below.

Nesting platform being installed at the Jacksonville Zoo.

Donna Bear-Hull (*bear-hulld@JaxZoo.org*), from the **Jacksonville Zoological Gardens** reports that this colony has doubled in size for the fourth yea in a row. In 2003, there were 84 nest starts with seven nest failures and the colony successfully fledged approximately 191 chicks. This compares to 40 nests with 111 chicks fledged in 2002. The productivity success rate was one of the highest in FL (see **Productivity of Wood Storks in North and Central Florida**). The Duval Audubon Society assisted Donna in monitoring the colony twice weekly as part of the Productivity Monitoring Initiative. Larry Bryan from SREL and Donna initiated a chick banding project at the Zoo during the 2003 breeding season. They were able to band 15 chicks from 5 nests. Twenty-six chicks which fell out of their nests were brought to the Zoo's rehabilitation center. Ten were successfully released, utilizing a soft release location (a holding pen near the nesting trees). They were banded prior to release and were re-sighted around the Zoo grounds on several occasions. With assistance from **Sue Maher** (*Sue.Maher@Disney.com*), Donna and Larry have also received a grant

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from **Disney's Animal Kingdom** to put a GPS solar powered satellite tag on adult Wood Stork to be captured at the Zoo. The accuracy of the new GPS satellite technology and the longer tag life-expectancy (several years) will begin to provide answers to questions such nest site fidelity, important feeding areas that support the Zoo colony, and adult survival rates. Other conservation efforts at the Zoo include installing three nesting platforms near the nesting trees and three in the impoundment/wetland area at the Wild Florida Exhibit.

Laurie Clarke (*Laurie.Clarke@dep.state.fl.us*) and **Amy Kalmbacher** (*amy.kalmbacher@dep.state.fl.us*), **FDEP** biologists, assisted in the Productivity Monitoring Initiative as they followed the Wood Stork's nesting efforts at two cypress domes located within the boundaries of the **Pumpkin Hill Creek State Preserve**. They monitored 47 nests in one dome and 21 in the other (68 total) which represented approximately 75% of the nesting effort at this site (see **Productivity of Wood Storks in North and Central Florida**). Conservation wise, Amy and Laurie have been working on the Preserve's Fire Management Plan to ensure that the colony sites are considered in the Burn Plan.

J.B. Miller (*millerjb@aug.com*), a biologist with the FDEP **Florida Park Service**, monitored the colony that is located within the recently acquired 8,000 acre tract of land that borders the Intracoastal Waterway south of St. Augustine. The St. Johns River Water Management District purchased the Matanzas Marsh property from Rayonier Paper Corporation. This purchase creates an area of protected lands of approximately 12,000 acres as it adjoins two other significant pieces of public lands, Favor Dykes State Park to the south and Moses Creek State Preserve to the north. The property will be split into two parts and the southern half will be managed by the Florida Park Service while the northern half (the section that contains the Wood Stork colony) will be managed by Florida's Division of Forestry. J.B. along with a Bert Charest, a St. Johns Audubon volunteer, utilized the Productivity Monitoring Intiative's protocols to document nesting success at this colony. This colony was significantly smaller at 18 nest starts in 2003 as compared to 120-150 in 2002. A note of interest is that a pair of Great Horned Owls nested within the colony utilizing an old stork nest.


Wayne Lasch

Amanda Whitaker (*AWhitaker@alligatorfarm.com*), the bird and mammal curator at the **St. Augustine Alligator Farm Zoological Park**, reports that at least 17 pairs of Wood Storks were successful at raising chicks at this relatively new nesting site for Wood Storks. There were several additional potential nests, however due to their location, the nests nor chicks could be confirmed. Amanda documented that the 17 nests had 2-3 chicks per nest and she estimates that they fledged approximately 45 chicks. The St. Augustine Alligator Farm is well known for it's multi-species wading bird colony and the staff are very excited about the Wood Stork colony and that it seems to be growing in size.

Rich and Ann Paul (*rpaul@audubon.org* and *apaul@audubon.org*) of **Audubon of Florida's Florida Coastal Islands Sanctuaries Program** report 247 nesting pairs at the Dot Dash Colony in the Braden River in Manatee County. Also, Rich has retired!!! (see **People on the Move**). We hope that he will help us keep up with Wood Storks in the Tampa Bay area. Rich, thanks for all the good work, technical assistance and information sharing. Good Luck and Best Fishes!

Ken Tracy (*ktracey@gte.net*) of the **Pasco County Audubon Society** continues to provide updates on several colonies in the Pasco County area.

Refuge Manager **Paul Tritak** (*paul_tritak@fws.gov*) of the **USFWS Pelican Island National Wildlife Refuge** reports that 123 nesting pairs of Wood Storks nested at the Pelican Island colony during the 2003 breeding season and successfully fledged an estimated 186 chicks. This compares to 176 nests and 238 chicks fledged in 2002.

For information regarding other Wood Stork colonies in North and Central FL, you should contact **Jim Rodgers** of the **FWC** at *jim.rodgers@fwc.state.fl.us* or **Billy Brooks** of the **USFWS** at *billy_brooks@fws.gov*.

SOUTH FLORIDA

The South Florida Wading Bird Report, which is edited by **Gaea E. Crozier** (*gcrozie@sfwmdlgov*) of the **South Florida Water Management District**, and **Dale E. Gawlik** (dgawlik@fau.edu) of **Florida Atlantic University** (*dale.gawlik@sfwmd.gov),* is a great resource regarding wading bird ecology in south FL. The 2003 Report is the eighth compilation of this report with the first being published in 1997. The following information on Wood Stork colonies in south FL are excerpts from the November 2003 South Florida Wading Bird Report. The 1997-2003 South Florida Wading Bird Reports can be found at the following website: (*http://www.sfwmd.gov/org/wrp/wrp_evg/projects/wading01*).

Jason Lauritson of **Audubon's Corkscrew Swamp Sanctuary** (*jlauritsen@audubon.org*) reports that Wood Storks initiated nesting at the Corkscrew Swamp Colony in January 2003. Fourteen aerial surveys were conducted via a fixed wing aircraft with complete coverage of the nesting area. Visual estimations were made counting each nest when the colony size was small, and estimating as the colony approached its maximum density. To improve accuracy of nest counts, slide photos were taken with a 70-200mm lens of the entire colony on each survey date from approximately 1000ft, circling the colony until full slide coverage was attained. Photos of each

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sub-colony were taken from 400ft during a single pass to assist in productivity estimates and stage of development. These flights occurred between Jan 27, 2003 and Jun 17, 2003 (42 person-hrs). Photos of each aerial survey were projected on a grid and analyzed. Photos from 1000' were used to identify the total number of possible nests. Slide photos taken from approximately 400' were further analyzed to determine what proportion of the colony were Wood Stork nests, Great Egret nests, loafing birds, or birds of indeterminate status, in order to reduce the error associated with the image quality of slides taken at 1000'. Nest productivity was also determined using the slides taken at 400'. Two-hundred and six nests were clearly visible in the 400' slide set taken on May 17th. There were 348 chicks occupying these nests, which yield a productivity of 1.69 chicks per successful nest. Season totals indicate an estimated 780 chicks fledging from approximately 1100 nest attempts, roughly 460 of these nests were successful. Productivity was 0.42 chicks per nest attempt. Rainfall levels were above average for the area in January, March, April and May. High winds associated with a late February stor m and a heavy rainfall event in mid-March seem responsible for a large portion of the nest failures in 2003.

Deborah Jansen (*deborah_jansen@nps.org*) of the **Big Cypress National Preserve** reports that searches for wading bird rookeries in Big Cypress National Preserve were conducted during the 3 times per week fixed-wing flights used to locate Florida panthers and during all routine helicopter work at the Preserve. A random search of a sample of previously active rookeries, including the only 2002 stork nesting site, was conducted on Feb 19, 2003. No activity was documented. Although the dry-down was initially normal, the above average rainfall from March through May may account for the lack of wading bird nesting in Big Cypress in 2003.

Peter Frederick from the **UF's Department of Wildlife Ecology and Conservation** (*pcf@mail.ifas.ufl.edu*) oversees monitoring efforts of wading bird colonies in Water Conservation Areas 2 and 3 (for the past 17 years), and at the Loxahatchee National Wildlife Refuge. This project also monitored nest success of Great Egrets, White Ibises, and Wood Storks, and continued studies of juvenile stork movements and survival; **see Survival and Movements of Juvenile Wood Storks**. Aerial and ground surveys were designed to systematically encounter and document nesting colonies. A Cesna 182, with observers on both sides, is used to fly east-west transects that are spaced at 1.6 nautical miles apart at an altitude of 800 feet. This method results in overlapping coverage on successive transects under a variety of weather and visibility conditions and have been utilized to survey this area since 1986.

Peter and his staff report that within Water Conservation Areas 2 and 3, Wood Storks nested at the Jetport colony (375 pairs) and at the Crossover colony (40 pairs). No Wood Stork nesting was documented within the Loxahatcheee NWR. Within the WCAs, Wood Storks nests were 2.1 times the average of the last 5 years and 3.9 times the average of the last 10 years. Peter noted abandonments of large numbers of nests by Wood Storks at these colonies. These failures can be attributed in large part to heavy rainfall that occurred several times during the season, particularly in late March.

Mary Beth Morrison (*mmorrison@swa.org*) of the **Palm Beach County Solid Waste Authority** reports that Breeding Bird Censuses (BBCs) were conducted in the SWA Roost by 2 observers every 8 weeks rom February – July 2003, representing approximately 12 person-hrs. During the BBC, all islands from 3 abandoned shell pits were systematically surveyed from a small boat, and the identified bird species and nest numbers were recorded. Surveys were conducted during the morning hours so as to minimize any burden caused by the presence of observers.

The SWA roost is located on spoil islands in abandoned shell pits that were mined in the early 1960s in Palm Beach County , FL (Lat. 26o46'41"N: Long. 80o08'32"W). The spoil islands consist of overburden material and range from 5 to 367 m in length, with an average width of 5 m. Islands are separated by 5-6.5 m with vegetation touching among close islands. The borrow pits are flooded with fresh water to a depth of 3 m. Dominant vegetation is Brazilian pepper (*Schinus terebinthifolius*), Australian pine (*Casurina spp.*), and melaleuca (*Melaleuca quinquenervia*), all nonnative species. Local features influencing the roost include: (1) the North County Resource Recovery Facility and landfill and (2) the City of West Palm Beach's Loxahatchee Watershed Preserve (=Water Catchment Area), a 44 km^2 remnant of the Loxahatchee Slough.

This report presents preliminary data for the 2003 breeding season. Typically nesting activities have been observed at this colony through September, and these surveys being reported are only through the end of July. Nest surveys were conducted on February 21st, Apr 9th, and Jun 10th 2003. Only the peak nest numbers are being reported for each of the bird species.

The estimated peak number of wading bird nests for the SWA Colony is 3,060 which represents a 6.8% increase from the 2002 season. The number of White Ibis, Tricolored Heron, Anhinga, Cattle Egret, and Great Blue Heron nests are higher during this year than the 2002 season. Wood Stork, Snowy Egret, Great Egret, and Little Blue Heron nest numbers appeared to be less than observed in 2002. There was a 34% decrease in Wood Stork nests from last year. However, the peak nest numbers may have been missed because there appeared to be a loss of Wood Stork nests after heavy rains (personal observation).

As part of the Productivity Monitoring Initiative, this colony was also monitored as a South Florida index colony. Seventy nests were followed through the nesting season, of which there were 45 (64.3%) failures and 25 (35.7%) successful nests. Six of the successful nests fledged one chick and 19 fledged 2. The mean number of young fledged from all nests (n=70) was 0.63 and from successful nests (n=25) was 1.76.

Lori Oberhofer (*lori.oberhofer@nps.gov*) and **Sonny Bass** (*sonny.bass@nps.gov*) from the **Everglades National Park** report that staff flew several wading bird colony surveys during the 2003 nesting season: 21 Jan, 19 Feb, 21 Mar, 4 Apr, 17 Apr, 7 May, 22 May, 5 Jun, and 14 Jul. Nesting began in January and increased through March and April. Most colonies had fledged all young by the end of May; however, several colonies were still active as of mid-August. An overall decrease of 14% in the numbers of nesting wading birds was observed

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compared to the 2002 nesting season. They located approximately 2,667 wading bird nests within 13 mainland colonies. Compared to the 2002 nesting season, the numbers of nesting Wood Storks decreased by 12%. The size of individual wading bird colonies was generally smaller than in previous years. Wood Storks nested in four colonies with the largest colony, Tamiami West, containing 400 nests. Wood Storks again nested at Cuthbert Lake (75 nests), Paurotis Pond (130 nests) and the Rodgers River (130 nests). Unfortunately , Cuthbert Lake, Paurotis Pond, and Tamiami West colonies experienced nest failures . The failures appeared to be associated with significant rain events that occurred near the middle and end of March. Rodgers River Bay was the only large traditional colony that did well this year. The Wood Storks and Great Egrets nesting there seemed to be unaffected by the rain events that led to failures in other colonies. The most prevalent species recorded nesting in mainland ENP colonies were Great Egrets, Wood Storks, Cattle Egrets, and White Ibis. (Also see **Survival and Movements of JuvenileWood Storks** for a productivity monitoring at the Tamiami West colony.)

Harris Neck National Wildlife Refuge

John Robinette (USFWS)

The first documentation of Wood Storks nesting at Harris Neck National Wildlife Refuge in coastal Georgia was in 1988. Since then, a carefully crafted plan - set in motion by Savannah Coastal Refuge Biologist John Robinette, refuge staff and a host of partners - has culminated in over 400 Wood Stork nests and a record-setting 857 chicks fledged in Spring 2003.

Charles Bear

The Harris Neck colony, now one of the lar ger Wood Stork nesting colonies in the southeast U.S., consistently had 100 to 150 nests each year, but growth did not take of until some imaginative planning took hold. The plan centered on meticulously constructed impoundments and islands, covering 40 acres, that protect chicks from predators and provide plenty of food. In addition, 150 artificial nesting platforms built on 20-foot posts were placed within the impoundments and are now used predominantly by Wood Storks for nesting. Cypress trees planted on islands that were constructed within the impoundment in 1994 are now large enough to support natural nesting activities and significant numbers of Wood Storks and other wading bird species are nesting in these trees.

This project enlisted various USFWS programs. Refuges and Ecological Services designed the colony area and impoundments, conducts monitoring surveys and bands pre-fledge chicks annually. Fisheries and Habitat Conservation and Hatcheries raised fish and stocked feeding ponds. Georgia and South Carolina Departments of Natural Resources also helps with research, nesting platform construction, and stocking the feeding ponds. Equally important were the private partners: ITT Raynier donated $5,000 for the water delivery system. Shearhouse Lumber, a small Savannah company, sold the nesting platform poles at wholesales prices. Armstrong Atlantica State University supplied technicians and interns. Savannah River Ecology Lab has conducted Wood Stork research at this site and other Geor gia colonies and published nearly a dozen papers to help others working with Wood Storks. Ducks Unlimited constructed nesting islands in places where the platforms couldn't be built. Even the local florist sold artificial leaves at costs to make the platforms resemble trees.

Status of Wading Bird Recovery in South Florida– 2003

John C. Ogden (jogden@sfwmd.gov), SFWMD

The purpose of this repo rt is to provide a regional integration and interpretation of wading bird nesting data from the Everglades Water Conservation Areas and Everglades National Park, in the context of the recovery goals established for wading birds by the Comprehensive Everglades Restoration Plan (CERP). These reports have been produced annually since 1996 for inclusion in the South Florida Wading Bird Report. Recovery of more historical wading bird nesting patterns in the greater Everglades basin will be measured using four parameters: (1) numbers of nesting pairs for six species, (2) locations of major nesting colonies, (3) timing of nesting for Wood Storks, and (4) frequency of supra-normal colonies (super colonies). Although the development of the CERP monitoring and assessment plan (MAP) and an "official" set of CERP assessment performance measures during the past year has been an essential step towards formalizing the restoration goals for wading birds in south Florida, numerical endpoints for these four parameters now need to be reviewed, refined or developed, as appropriate. The information on nesting patterns now being collected is being used to better define the pre-CERP condition for wading birds – the baseline from which wading bird responses to

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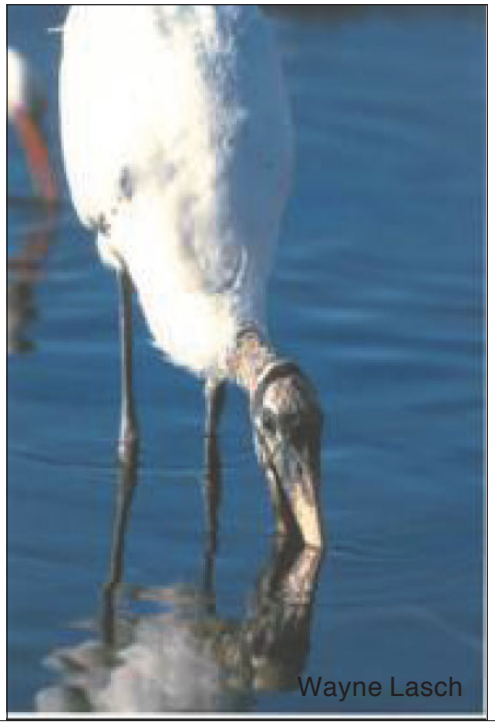
...Status of Wading Bird Recovery in South Florida– 2003 continued from page 17

CERP will be measured. Information used in this annual status report is extracted from data collected during aerial and ground surveys of nesting colonies in LNWR, WCAs 2 and 3, and mainland ENP, and reported in more detail in other sections of this South Florida Wading Bird Report.

2003 Results

Numbers of Nesting Birds: In 2003, the reported total number of nesting pairs (rounded to the nearest 100) for the five mainland, indicator species was 8,800 Great Egret pairs, 1,400 Snowy Egret pairs, 1,700 Tricolored Heron pairs, 12,400 White Ibis pairs and 1,100 Wood Stork pairs. The total for the five species in 2003 was 25,400 pairs, compared to 8,000 pairs in 1996, 8,300 pairs in 1997, 6,900 pairs in 1998, 21,600 pairs in 1999, 32,900 pairs in 2000, 30,600 pairs in 2001, and 60,100 pairs in 2002. In addition, an estimated 1,100 pairs of Wood Storks nested at Corkscrew Swamp Sanctuary in 2003. Seasonal Timing of Nesting: In general, the sub-regional colony survey reports provide information on numbers of nesting pairs, locations of colonies, and to a lesser extent, on nesting success. In these reports, information on timing of nesting is often incidental or omitted. The 2003 sub-regional reports did not provide enough information on timing for me to be able to comment on this years' patterns. The restoration goal for Wood Storks is to shift the initiation of nesting to a December-January time frame (January - March in most recent years), which more closely matches pre-C&SF Project nesting patterns for storks in the Big Cypress and southern Everglades. Locations of Colonies: The number of pairs for the five indicator species that nested in the southern Everglades ecotone region of Everglades National Park in 2003 was an estimated 1,200 pairs, or about 4.5% of the total Everglades nesting effort. The percentage nesting in the southern ecotone region probably exceeded 90% in many years during the 1930s and early 1940s, averaged 26% during the years 1986-1995, was 11% in 1996, and has been less than 5% in all years since 1997. The restoration goal is to recover large, sustainable nesting colonies in the marsh-mangrove ecotone region of the southern Everglades, where the largest known colonies occurred in the pre-C&SF Project Everglades.

Recovery of "Supra-Normal Colonies": The recovery of a "super colony" nesting pattern is a new performance measure and restoration goal for wading birds in the Everglades. This restoration goal is based on a paper published by Frederick and Ogden (2001) that describes a historical pattern of supra-normal nesting events in the Everglades. The presence of these regional-scaled, supernormal nesting events in the historical Everglades was one of the defining characteristics of this ecosystem. It was in these occasional years of supra-normal nesting that the huge "rookeries" formed in the old Everglades. For the period 1931-1946, supra-normal nesting events occurred in 25% of the years, with an average regional nesting effort of 85,000 pairs. For the recent period, 1986-1998, supra-normal nesting events occurred in 15% of the years, with an average nesting effort of 24,000 pairs. The restoration goal is to recover the frequency and magnitude of these supranormal nesting events.


Wayne Lasch

Discussion

For the four parameters of wading bird nesting patterns that will be used to assess responses to the CERP and other restoration programs in south Florida (numbers of pairs, timing, locations, supra-normal nesting years), the baseline or pre-CERP condition for each seems to be reasonably understood except for numbers of nesting pairs. The percentage of birds nesting in the southern Everglades ecotone region has settled in at < 5% annually since 1997; storks generally initiate nesting in February or March (except earlier in the wetter years); and supra-normal nesting events are smaller and less frequent than during the historical period, 1931-1946. The numbers of nesting pairs in the mainland colonies (keeping in mind that the Big Cypress and Lake Okeechobee regions continue to be un-surveyed!) has in recent years shown increases for all species, which raise challenges for those who are attempting to characterize pre-CERP patterns. The attached table shows three-year running averages for nesting pairs of Great Egrets, Snowy Egrets and Tricolored Herons (combined), White Ibis, 2003. The numbers for the egrets, herons, ibis and storks are from the mainland colonies in the three WCAs and ENP, while the spoonbill numbers are from Florida Bay. The spoonbill running averages are incomplete because total surveys of the bay were not conducted in 1993-1998 and in 2000 (J. Lorenz). The table shows that Great Egrets have been increasing almost throughout this period of years, doubling their numbers between the 1986-1988 and 1994-1996 periods, and doubling again between the 1994-1996 and 2001-2003 periods. As mentioned in previous annual status reports, the number of Great Egrets nesting in this region of south Florida equals or exceeds the numbers estimated during the 1930s-1940s (Ogden 1994).

The other mainland species reported in the table have all shown increases, but for the most part only since the late 1990s. The running averages for snowies and tricoloreds (combined) and for storks generally remained constant from the mid-1980s to late 1990s, but then abruptly increased beginning in the 1999-2001 period for the egrets/herons, and in the 1998-2000 period for storks. With the exception of a substantial bump in nesting effort by ibis in the early 1990s (entirely consistent with the nomadic nesting patterns of ibis; see Frederick and Ogden 1997), ibis showed a similar dramatic increase in nesting beginning in the 1998-2000 period.

A major unanswered question at this time is whether the increased nesting effort since the late 1990s will be sustained. If these increases were at least in part due to the favorable rainfall and drying patterns in the Everglades during these recent years, then we might expect to see sub-

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stantially reduced nesting in future dryer years, and in years with unseasonable winter rains. This year, 2003, may have been a demonstration of the effects from unseasonable rains in March, which apparently caused reductions both in nesting numbers and nesting success.

Literature Cited

Frederick, P.C. and J.C. Ogden. 1997. Philopatry and nomadism: contrasting long-term movement behavior and population dynamics of White Ibis and Wood Storks. Colonial Waterbirds 20: 316-323.

Frederick, P.C. and J.C. Ogden. 2001. Pulsed breeding of long-legged wading birds and the importance of infrequent severe drought conditions in the Florida Everglades. Wetlands 21: 484-491.

Ogden, J.C. 1994. A comparison of wading bird nesting colony dynamics (1931-1946 and 1974-1989) as an indication of ecosystem conditions in the southern Everglades. Pp. 533-570 in, Everglades. The ecosystem and its restoration (S.M.Davis & J.C. Ogden, eds.). St. Lucie Press, Delray Beach, FL.

Productivity of Wood Storks in North and Central Florida

*James A. Rodgers Jr.,Stephen T. Schwikert;, LeAnn White (FWC) *

The Wood Stork (*Mycteria americana*) once was a common breeding species throughout the southeast United S tates. However, precipitous declines in the species' range and population occurred during the mid-1900s (Kushlan and Frohring 1986, Ogden *et al.* 1987). Ultimately, the United States population was listed as endangered in 1984 (USFWS 1984). While the number of stork nests and colonies in Georgia and South Carolina appeared to increase during the 1980s and 1990s, storks were still experiencing nesting related problems in Florida, especially south Florida (Coulter *et al.* 1999).

Wood Stork fledging success often is variable among different years and colonies (Holt 1929, Kahl 1964, Ogden et al. 1978, Clark 1978, Ehrhart 1979, Hopkins and Humphries 1983, Rodgers and Schwikert 1997) suggesting food resources are the proximate factor in differences in nestling survivorship and fledging rates. Based on statewide surveys conducted by GFC/FWC personnel, stork colonies increased from 32 colonies during 1976-78 (Nesbitt *et al.* 1982) to 52 colonies during 1986-87 (Runde *et al.* 1991), but decreased to 34 colonies in 1999 (Rodgers *et al.* 2002). Storks also continued the trend of exhibiting a shift to an increased number of smaller colonies and fewer large colonies during the last two surveys: 46.9% of the colonies in the 1970s were #250 birds compared to 77.0% in the 1980s and 66.7% in 1999, while 37.5% of the colonies in the 1970s were >500 birds compared to 5.7% in the 1980s and 15.2% in 1999. The most recent surveys indicated about 1,585 stork nests at 17 colonies during the drought year of 2001 (Slay and Bryan 2001) but 6,622-7,732 nests at 47 colonies in 2002 (Meyer and Frederick 2002) in Florida.

One of the objectives of the Wood Stork Recovery Plan (i.e., 3.3 Monitor productivity of stork populations) identified productivity levels exceeding a minimum standard to ensure continued viability of the U.S. stork population (USFWS 1997, 2000). Specifically, knowledge of the number of fledged young per nest must be determined for a representative number of colonies during the same year for a minimum of 3 years. A reclassification from an endangered to threatened status could be accomplished when there are 6,000 nesting pairs and annual productivity is greater than 1.5 fledglings/nest averaged over three contiguous breeding seasons. Currently, the Wood Stork has a biological score of 26.3 and an action score of 14, with a monitoring score of 4 and a research score of 5, in the FWC bird ranking for the year 2003.

Thus, the primary goal of this study is to gather productivity data for storks nesting in Florida in order to examine the variation and trends in fledging success within and among colonies and years. These data for the reproductive success of the north and central Florida stork colonies would then be compared within the metapopulation of storks in the southeast United States by examining the effects of colony size and geographical location on breeding success within and among colonies and years. These data ultimately may be used to determine if the stork population in the U.S. meets recovery criteria for down-listing the species.

Study Population and Methods

Study area

Based on information from the previous statewide waterbird atlas conducted by GFC/FWC personnel (Nesbitt *et al.* 1982, Runde *et al.* 1991, Rodgers *et al.* 2002) and 2002-03 statewide surveys of Wood Stork colonies funded by the USFWS, stork colonies were randomly selected from the 12-15 active sites in north and central Florida based on number of nests, accessibility and distribution across the state. These sites included colonies located in both coastal and interior counties

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(Appendix).

Study Approach

Based on previous experience with monitoring stork productivity and requirements for a representative sample size for statistical analyses, either all nests (colonies #100 nests) or a sample of the nests (i.e., 25-70% of nests at larger colonies) were monitored on a biweekly schedule during the breeding season. The study is designed to monitor colonies with differences in nest numbers and densities, at interior and coastal county sites, and with latitudinal and longitudinal dispersal. However, because stork colonies exhibit considerable variation in nest numbers and breeding status among years (Ogden *et al.* 1980, 1987, Rodgers *et al.* 1987, Rodgers and Schwikert 1997), there is a high probability that not all colonies will be active or have similar nest numbers every year of the study . This may result in missing colony-years and ultimately cause an unbalanced study design.

Wood Stork colonies were visited every 1-2 weeks throughout the breeding season to avoid temporal biases associated within nesting seasons (Rodgers and Schwikert 1997). Care was taken to reduce researcher effects on the breeding storks and other species of colonial waterbirds by minimizing nest monitoring during pair-formation and early egg-laying periods. Colonies were visited during the cooler morning and late afternoon and no visits occurred during inclement weather. The time spent at each nest was minimized by the use of two people to observe and record data and map nest/tree distribution. Binoculars were used to monitor nests from a distance within high-density mixed-species subcolonies when the nestlings were visible and capable of leaving the nest. After the nestlings were 3 to 4-weeks old, all nests were counted from a distance with binoculars to avoid prefledging of nestlings. Most stork nests and trees were individually marked with numbered, colored flagging tape.

Colony	Number [b]	Mean	Std	Rank[c]
Jacksonville Zoo	82	2.21	0.98	A
Cypress Creek	163	1.85	1.01	AB
New Port Richey	215	1.85	1.14	AB
Lake Russell	65	1.71	1.03	BC
Little Gator Creek	171	1.68	1.07	BC
Pumpkin Hill	68	156	1.16	BCD
Lake Rosalie	102	1.52	0.92	BCD
Dee Dot	188	1.51	1.21	BCD
Matanzas Marsh	18	1.39	1.20	CDE
Lone Palm	153	1.36	0.99	CDE
Ochlockonee	71	1.35	1.06	CDE
Croom	292	1.29	1.07	DE
Chaires	207	1.06	1.09	E
Devils Creek	14	0.21	0.58	F
Summary totals	1809	1.49	1.11	

[a]Values given are per nest.
[b]Number represents the number of nests monitored in each colony, not the total colony size.
[c]ANOVA/LSMeans tests for among colony mean comparisons, P=0.05. Colonies with the same letter are

Statistical analysis

Data are represented and analyzed as a colony-year unit. Thus, a colony monitored for 3 years or 3 colonies monitored during one year are represented by 3 colony-years. Fledging rates were calculated on a per nest (fledglings/nest) basis for both all nests initiated and successful nests (fledging $ 1 bird). Sources of nest failure were determined when possible.

Statistical analyses were made with the SAS System (SAS Institute, Inc. 1985). Unless stated otherwise, values represent the mean± s.d. Statistical analyses of reproductive variables were made only for colony-years with $20 nests. Prior to pairwise comparisons, the data were tested for normal distribution with the Shapiro-Wilk statistic using the UNIVARIATE procedure (SAS Institute, Inc. 1990a) and for homogeneity of variances with Bartlett's likelihood ratio test using the DISCRIM procedure (SAS Institute, Inc. 1990b). The UNIVARIATE procedure also was used to calculate interquartile values. Appropriate nonparametric or parametric statistical analyses were used for fledging success variables. The MEANS procedure was used to calculate standard descriptive statistics including mean, standard deviation, and 95th confidence intervals. An inverse variance weighting option was used with the MEANS procedure to account for the uneven sample sizes among colonies. We assumed independence among colonies and a constant correlation within each colony.

Because of the potential unbalanced design of this study due to no nesting activity at colonies in some years, the MIXED procedure (SAS Institute, Inc. 1992) will be use to analyze geographical trends among colonies at the end of the 3 breeding seasons of the study The MIXED procedure fits mixed linear models (generalizations of standard linear models) using both fixed (e.g. latitude, longitude, colony size, nesting density) and random effects (e.g. colony, year, colony*year). Thus colony and year can be used as class variables, while latitude, longitude, nest numbers and nesting density will be fixed covariates when colony-years are pooled.

All data will be stored at the Wildlife Research Laboratory in Gainesville and with the Division of Wildlife Technical Support Service's staff in Tallahassee. Annual and final reports will be deposited at \\Wildnet\BWDC\BWDC Projects\Progress Reports\FY02-03 Progress Reports and updates thereafter. Copies of all reports will be provided to cooperators and the USFWS at the end of the field season.

Results and Discussion

The average fledging rate of Wood Storks at 14 colonies in north and central Florida during 2003 was 1.49±1.11 fledglings/nest (Table 1). The estimated 95th confidence interval for fledging success for all colo-

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nies was 1.43 to 1.54 fledglings/nests. For only successful nests (nests that fledged at least 1 stork), the average fledging rate was 2.15±0.64 fledglings/nest (n=1,281 nests). About 70.8% of monitored nests fledged at least one bird.

Significant differences existed among colonies in the mean fledging rate, which ranged from 0.21 to 2.21 fledglings/nest (Table 1). A cluster of colonies in Pasco and Hillsborough counties (Cypress Creek, New Port Richey) in the west-central region and the Jacksonville Zoo in the northeast region of Florida exhibited the greatest fledging rates. Colonies that exhibited fledging success below the lower 95th confidence interval of 1.41 fledglings per nest appeared to be widely distributed both in north and central Florida. However, the two most northern and western colonies of Ochlockonee and Chaires in Leon County both exhibited below average fledging success.

An examination of the distribution of the number of fledglings per nest provided more insight into the fledging success within each colony (Table 2). Cypress Creek and Jacksonville Zoo exhibited high fledging rates due to below average number of complete nest failures (i.e., no fledglings) and above average number of 3-fledgling nests. In contrast, Chaires exhibited a low fledging rate due to below average number of 2-fledgling and 3-fledgling nests and above average number of complete nest failures.

		Percent of nests with fledglings				
Colony	Number*	0	1	2	3	4
Chaires	207	45.4	13.5	30.4	10.6	0
Ochlockonee	71	31.0	15.5	40.9	12.7	0
Pumpkin Hill	68	29.4	8.8	39.7	20.6	1.5
Jacksonville Zoo	82	9.8	9.8	30.5	50.0	0
Dee Dot	188	34.6	4.8	37.8	21.3	1.6
Matanzas Marsh	18	38.9	0	44.4	16.7	0
Cypress Creek	163	17.2	8.0	47.9	27.0	0
New Port Richey	215	22.8	5.1	37.2	34.4	0.5
Croom	292	35.6	11.3	42.1	10.6	0.3
Devils Creek	14	85.7	7.1	7.1	0	0
Little Gator Creek	171	25.2	2.3	52.1	20.5	0
Lone Palm	153	28.8	15.0	47.7	8.5	0
Lake Russell	65	20.0	9.2	52.3	16.9	1.5
Lake Rosalie	102	18.6	21.6	49.0	10.8	0
Summary totals	1809	29.2	9.7	41.5	19.2	0.4

*Number represents the number of nests monitored in each colony, not the total colony size.

[Table]

Nest failures appeared to be evenly distributed during the breeding season among most colonies. However, there were three colonies that exhibited a sizable number of nests failures associated with severe weather (wind speeds exceeding 20 mph and rainfall exceeding 1 inch per hour) during a short time interval. Chaires (prior to May 13), Dee Dot (prior to May 23), and Croom (prior to June 17) all experienced a large number of nests that either were abandoned or collapsed as evidenced by unattended nests, fallen nest structures, and/or dead nestlings under the nest trees. The low fledging rate at Devils Creek was the result of an apparent abandonment of all but two of the nests by parent birds.

Comparative data on Wood Stork productivity in Florida dates mostly from the mid-1970s to mid-1980s but appears to be similar to the results of this current study. Ehrhart (1979) reported a rate of 1.7 fledglings/nest for storks nesting at Merritt Island in 1979, while Rodgers *et al.* (1987) reported an average rate of 0.79 (range 0.21-1.34) fledgling/nest for 14 colonies in north and central Florida during 1981-85. The rate of 1.27 fledglings/nest during 1981-85 was higher than the 1.06 fledglings/nest rate in 2003 at Chaires but the 1.54 fledglings/nest rate during 1981-85 was similar to the 1.51 fledglings/nest rate in 2003 at Dee Dot. Ogden *et al.* (1978) reported an average of about 2.0 fledglings for successful nests in south Florida and Clark (1978) reported a range of 1.4-2.5 fledglings for successful nests at Merritt Island. These published rates are similar to the average of 2.16 fledglings/nest for successful nests in this study .

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REFERENCES

Clark, E. S. 1978. Factors affecting the initiation and success of nesting in an east-central Florida Wood Stork colony. Proceedings of the Colonial Waterbird Group 2:178-188.

Coulter, M. C., J.A. Rodgers, Jr., J. C. Ogden, and F C. Depkin. 1999. Wood Stork (*Mycteria americana*). *In* The Birds of North America, No. 409 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Ehrhart, L. M. 1979. Threatened and endangered species of the Kennedy Space Center: threatened and endangered birds and other threatened and endangered forms. John F . Kennedy Space Center, Florida: Contract report 163122, KSC TR 51-2, volume IX, part 2. National Aeronautics and Space Administration.

Girard, G. T., and W. K. Taylor. 1979. Reproductive parameters for nine avian species at Moore Creek, Merritt Island National Wildlife Refuge, Florida. Florida Scientist 42:94-102.

Holt, E.G. 1929. In the haunts of the Wood Ibis. Wilson Bull. 36: 2-18.

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Hopkins, M. L., Jr., and R. L. Humphries. 1983. Observations on a Georgia Wood Stork colony. Oriole 48: 36-39.

Kahl, M. P., Jr. 1964. Food ecology of the Wood Stork (*Mycteria americana*). Ecological Monographs 34:97-117.

Kushlan, J. A., and P. C. Frohring. 1986. The history of the southern Florida Wood Stork population. Wilson Bulletin 98:368-386.

Meyer, K. D., and P. C. Frederick. 2002. Survey of Florida's Wood Stork (*Mycteria americana*) nesting colonies, 2002. Final report submitted to the USFWS, Jacksonville, Florida.

Nesbitt, S. A., J. C. Ogden, H.W. Kale, II, B.W. Patty, and L.A. Rowse. 1982. Florida atlas of breeding sites for herons and their allies: 1976-78. FWS/OBS-81-49. Office of Biological Service, U.S. Fish and Wildlife Service, Washington, D.C.

Ogden, J. C., J. A. Kushlan, and J.T. Tilmant. 1978. The food habits and nesting success of Wood Storks in Everglades National Park 1974. Washington, D.C.: U.S. National Park Service Report no. 16.

Ogden, J. C., H. W. Kale, II, and S. A. Nesbitt. 1980. The influence of annual variation in rainfall and water levels on nesting by Florida populations of wading birds. Trans. Linnean Society of New York 9: 115-126.

Ogden, J. C., D. A. McCrimmon, Jr., G. T. Bancroft, and B. W. Patty. 1987. Breeding populations of the Wood Stork in the southeastern United States. Condor 89:752-759.

Rodgers, J. A., Jr., A. S. Wenner, and S. T. Schwikert. 1987. Population dynamics of Wood Storks in north and central Florida, USA. Colonial Waterbirds 10:151-156.

Rodgers, J. A., Jr., and S. T. Schwikert. 1997. Breeding success and chronology of Wood Storks *Mycteria americana* in northern and central Florida, U.S.A. Ibis 139:76-91.

Rodgers, J. A., Jr., P. S. Kubilis, S. A. Nesbitt, M. F. Delany, K. T. Bowman, J. B. Dodge, R. K. Felix, Jr, and J. Swan. 2002. Atlas of breeding sites for colonial waterbirds in Florida during 1999. Florida Fish and Wildlife Conservation Commission, Bureau of Wildlife Diversity Conservation, 620 South Meridian Street, Tallahassee, Florida 32399-1600.

Runde, D. E., J.A. Gore, J. A. Hovis, M. S. Robson, and P.D. Southall. 1991. Florida atlas of breeding sites for herons and their allies—update 1986-89. Tallahassee, Florida: Nongame Wildlife Program Technical Report no. 10, Florida Game and Fresh Water Fish Commission.

SAS Institute, Inc. 1985. Statistical analysis system user's guide: statistics. Cary, North Carolina: SAS Institute.

SAS Institute, Inc. 1990a. SAS procedures guide, version 6. Cary, North Carolina: SAS Institute.

SAS Institute, Inc. 1990b. SAS/STAT user's guide, version 6, volume 1. Cary, North Carolina: SAS Institute.

SAS Institute, Inc. 1992. SAS technical report P-229, SAS/STAT software: changes and enhancements, release 6.07. Cary, North Carolina: SAS Institute.

Slay, C., and L. Bryan. 2001. Aerial surveys of Wood Stork nesting colonies in Florida May 2001. Coastwise Consulting, Incorporated, Athens, Georgia. Final report submitted to the USFWS, Jacksonville, Florida.

USFWS. 1984. U.S. breeding population of the Wood Stork determined to be endangered. Fed. Reg. 49:7332-7335.

USFWS. 1997. Revised recovery plan for the U.S. breeding population of the Wood Stork. U.S. Fish and Wildlife Service, Atlanta, Georgia.

USFWS. 2000. Wood Stork (*Mycteria americana*). Pages 183–213 *in* Multi-species recovery plan for south Florida. U.S. Fish and Wildlife Service, Vero Beach, Florida.