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A COMPARISON OF DIRECT AND FLIGHT-LINE COUNTS AT A WOOD STORK (*Mycteria americana*) COLONY IN NORTH FLORIDA

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Abstract.—Flight-line counts, in which adult birds are tallied as they fly in and out of a nesting colony, provide an alternative to direct counts of nesting wading birds. In this study, a Wood Stork (*Mycteria americana*) colony in Leon County, Florida, was monitored from 1997-2004 with multiple annual visits using both direct nest counts and flight-line counts. In 1999 a drought caused drying of the surrounding wetland, and the colony was abandoned for two years, but returned in 2002. Both the flight-line and direct counts detected the colony abandonment, absence, and re-colonization. The direct count method was able to detect a smaller colony size after the re-colonization, which the flight-line counts did not detect due to greater within-season count variability and lower statistical power. The flight-line counts can detect changes of large magnitude and avoids any disturbance, so it may be a suitable technique for volunteers.

Florida is home to 18 nesting species of colonial waterbirds (FWC 2003). The Wood Stork (*Mycteria americana*) is Endangered, and seven additional waterbird species are Threatened or Species of Special Concern in the state (FWC 2008). Monitoring size and species composition is key for proper management and protection of a colony. Colonial birds present unique problems in counting because entry into the colony may cause wide spread disturbance and may be risky for the observer (e.g. alligators). Furthermore, managing agencies often have insufficient staff to make regular visits to colonies, so would like to use volunteers. The flight-line counts are recommended for use by volunteers of Florida Audubon's Project ColonyWatch because direct counts may not be possible due to accessibility, canopy closure, and a desire to avoid disturbance (Paul and Paul 2004).

The flight-line technique provides an index to a population of wading birds by counting the number of adults flying in and out of the colony. Erwin and Ogden (1979) and Erwin (1981) computed a regression equation between flight-line and direct nest counts. Strong et al. (1994) developed predictive regression equations to use flight-line counts to predict the number of White-crowned Pigeon (*Columba leucocephala*) nests on selected Florida Keys.

In order to assume the initial regression is applicable to other species, colonies, or years, assumptions must be made about the biology of the wading bird colonies (Cobb 1994):

1. there is no annual or seasonal variation in wetland conditions, prey base, synchronicity of nesting in the colony, or the distance to foraging areas
2. there are consistent effects of tide, time of day, nesting phase, species, and colony location on the regression between flight counts and the number of nests, and
3. the placement of power lines, clearings, and topology of a particular colony does not affect the flight rates or ability to count at a particular colony (also Shimada 2001).

One application of flight-line data would be to determine if changes in colony abundance can be detected within a year, or from year to year. This study examined how well the flight-line index can detect changes in Wood Stork abundance at a single site.

STUDY SITES AND METHODS

Study site.—Counts were made at a mixed-species, inland wading bird colony "Ochlockonee North" (Colony #592003; Runde et al. 1991, Rodgers et al. 1999, Rodgers et al. 2008) of about 1 ha and located one km east of the Ochlockonee River in Leon County, Florida (N 30°32.55', W 84°22.82'). Wood Storks have been documented nesting at this site since 1984, but they may have nested here as early as 1976 (J. Rodgers *in* BSLR 1991). Nesting was in a black gum (*Nyssa sylvatica*) forested wetland, which formed a peninsula extending into a small pond. The colony was visible from a CSX railroad right-of-way, primarily to the east, which bordered over half the wetland (Cobb et al. 1995). The railroad tracks and right-of-way provided an elevated walkway for direct counting of the entire colony without disturbing nesting birds, and a vantage point for observing flights of the storks. Lake Jackson, a shallow 1,600 ha lake located 2.5 km southeast of the colony, was used as a feeding area.

C*ount methods*.—During each nesting season from 1997 to 2004, I visited the colony every 2-3 weeks between 0900 and 1100 EST during non-rainy weather and when wind was <20 kph. From the railroad right-of-way, I first counted the nests in the colony and then counted the adult Wood Storks flying in and out of the colony for 30 min (Paul 1996). To minimize observer expectancy bias (Balph and Romesburg 1983), counts were not tabulated until later in the day.

A regression between the number of nests observed by direct counts and number of adults observed flying in and out of the colony during the flight-line counts was computed for each year nesting occurred. Because zero and very low counts would not be useful for estimating colony abundance, regressions were performed for peak nesting, which I defined as the time period around the highest nest count and adjacent dates when the count was within 65% of the high count. The regression from the initial year of 1997 was applied to each subsequent year's data to determine the applicability of regression estimates from year to year. The ratio of the direct count to the 30-min flight-line totals was also computed. Because the flight-line method assumes a consistent flight ratio throughout the season, I compared the flight rate from early and late in the season. The annual mean of counts at the beginning of the study (1997-99) and the end of the study (2002-04) was compared to determine if the two methods could detect a change in colony size.

Because within-year variation in counts affects the survey's ability to detect a multi-year trend if one exists (Cobb et al. 1996), I calculated the mean and coefficient of variation (CV = standard deviation/mean) of both the direct and flight-line counts for the peak nesting period. Based on the observed annual variation of both the flight-line and direct counts, and the average number of annual visits, I performed Monte Carlo simulations (Cobb et al. 1996) to determine the number of years required to detect an annual 5% decline in nesting. This technique uses PC-SAS[R] to randomly generate annual count data based on the observed mean, CV, number of visits, and percent annual decline, and then runs linear regression on the generated data. A thousand trials were generated and tabulated to determine the number of years of monitoring it would take to detect a 5% annual decline with $\alpha = 0.05$ and $1-\beta = 0.80$.

Results

Wood Storks were observed nesting on 54 of 85 visits made to the colony from 1997 to 2004 (Table 1). The worst drought on record in the Florida Panhandle started in 1998 (NDMC 2000; Verdi et al. 2006), and resulted in drying of the pond around the colony in the summer of 1999, and the pond continued to be dry in 2000 and 2001. Additionally in September 1999, sinkholes opened and drained Lake Jackson (Macmillan and McGlynn 2000) and it remained low through the remainder of the study. The colony was abandoned late in the season in 1999. While chicks and fledglings were present through August in most years, the last nest, chick and fledgling in 1999 were seen on 27 June, and the last flight of adults was observed on 13 June. No storks nested in 2000 and 2001, but the colony was active again in 2002 through 2004.

The flight-line counts roughly tracked the direct counts (Fig. 1). The ratio of Wood Storks nests to adult storks flying in and out for 30 min averaged 2.3. This ratio was consistent (2.3 to 2.6, CV = 5%) for 5 of the 6 active years, but for 1998, the ratio was just 1.5 (Table 1). The ratio did not differ significantly between April-May and June-August (April-May ratio = 2.45, June-August = 2.15, $p = 0.45$).

The slope and y-intercepts of the regression equations between the direct counts and flight-line were different each year (Table 2). For two of the first three years, the regression equation was significant ($p < 0.05$), but was not significant in any of the three years after the wetland drying. Applying the first year's regression equation to the next two years (1998 and 1999) showed a significant fit ($p < 0.05$) but accounted for little of the variation (Table 2). The first year's regression equation did not significantly fit the final three years' (2002-2004) data ($p > 0.05$).

Both the direct and the flight-line methods detected the abandonment of the colony in the summer of 1999, the absence of the colony in

Table 1. Comparison of direct counts of nest and flight-line counts (30 min) of adult Wood Storks from 1997-2004 at Ochlockonee North Colony, Leon County, Florida.

			Peak Direct counts			Flight-line			Direct/Flight-line
Year	N[a]	Peak Dates (N)[b]	Mean	CV[c]	High	Mean	CV	High	ratio
1997	10	3/23-5/5 (4)	79	17%	94	33	50%	55	2.5
1998	14	4/4-7/11 (7)	67	16%	82	52	52%	87	1.5
1999	14	3/27-5/1 (3)	76	20%	85	30	17%	34	2.3
2000	9	Colony inactive							
2001	5	Colony inactive							
2002	10	5/11-8/10 (5)	48	22%	62	36	23%	43	2.4
2003	13	4/6-5/25 (4)	60	12%	70	22	55%	39	2.6
2004	10	4/1-7/25 (8)	55	15%	71	34	101%	116	2.5
Mean	10			17%			50%		2.3

[a]Total of 85 visits, with nesting observed on 54.
[b]Peak dates based on maximum count and period around that count.
[c]CV = Coefficient of variation (standard deviation/mean).

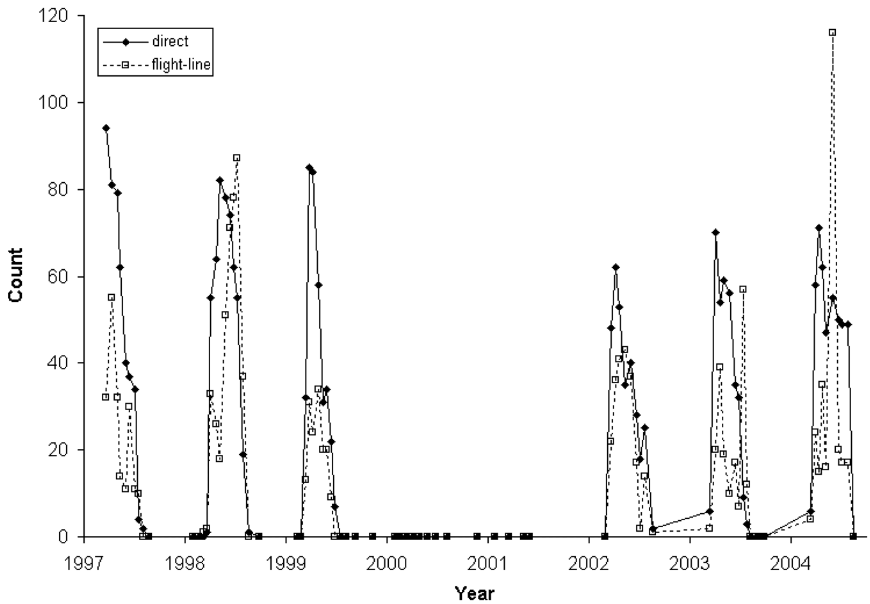

Figure 1. Direct and flight-line (30 min) counts of Wood Storks at Ochlockonee North Colony, Leon County, Florida from 1997 through 2004.

2000 and 2001, and the subsequent presence of the colony in 2002 - 2004. Based on the direct counts, the colony was smaller during the re-colonization than before the abandonment ($\bar{x}^{1997\text{-}99}$ = 74 nests, $\bar{x}^{2002\text{-}04}$ = 54 nests, t = 3.92, p = 0.02, 1-β = 0.84). The flight-line counts however, did not detect a significant decrease in colony size during the re-colonization ($\bar{x}^{1997\text{-}99}$ = 38 count in 30 min, $\bar{x}^{2002\text{-}04}$ = 32 count in 30 min, t = 0.74, p = 0.49, 1-β = 0.05).

The CV of the direct counts within a year was smaller than the CV for flight-line counts in 5 of the 6 years (Table 1), and the average annual CV for direct counts was 17% versus 50% for the flight-line counts. Based on the Monte Carlo simulations, using the average CV of 17% from the direct counts, and 10 annual visits, it would take an estimated 10 years of monitoring to detect a 5% annual decline, while with flight-line counts (CV of 50%), it would take 25 years to detect a 5% annual decline. The higher variability of counts with the flight-line method thus results in reduced statistical power (1-β) to detect a population trend if one exists.

Table 2. Linear regression between 30-min flight-line counts and direct count of nests of Wood Storks from 1997 – 2004 at Ochlockonee North Colony, Leon County, Florida.

				Applying 1st year[a]	
Year	Equation: Direct Count=	p of slope	r^2	P	r^2
1997	15.5 + (1.51 * Flight-line)	0.02	0.53	----------	
1998	26.7 + (0.55 * Flight-line)	0.10	0.22	0.03	0.31
1999	4.5 + (2.10 * Flight-line)	0.01	0.63	0.02	0.72
2000	Colony inactive				
2001	Colony inactive				
2002	57.4 - (0.27 * Flight-line)	0.73	0.04	0.09	0.59
2003	63.3 - (0.17 * Flight-line)	0.73	0.07	0.98	0.00
2004	54.8 + (0.01 * Flight-line)	0.91	<0.01	0.43	0.02
All years	30.2 + (0.52 * Flight-line)	<0.01	0.20	<0.01	0.20

[a]The regression equation from 1997 is applied to each subsequent year and p and r^2 included.

DISCUSSION

Project ColonyWatch (Paul and Paul 2004) suggests using a simple ratio of 1.5 times the total adults flying in and out of the colony for an hour, to get an estimate of the number of pairs in the colony. Based on the half-hour flight-line counts from this study, the average ratio for an hour would be 1.15 during peak nesting periods. Therefore the "standard" 1.5 multiplier would overestimate the number of nesting pairs by 30%.

The different slopes and y-intercepts of the regression equations for each year, suggest that an equation derived from one year would not be applicable to another year. The high y-intercepts and inverse relations of the direct and flight-line regression equations after the drying were probably an artifact of the high variability. While Lake Jackson was dry, the need for new feeding areas may have changed flight patterns (e.g., Bryan and Coulter 1987).

Although young chicks have been documented to feed more frequently than older chicks (Coulter et al. 1999) this study did not see a significant difference between flight rate early and late in the season. Erwin and Ogden (1979) showed the phase of nesting cycle had the greatest effect on flight traffic for four wading bird species, but they did not include Wood Stork. Assumptions about a consistent flight rate within a year are confounded by the asynchronous nesting of chicks, the need of an adult present for protection during the chicks first three weeks, and the differing feeding rates and amounts as the chick ages (J. A. Rodgers, Jr., Pers. Comm.).

Based on a single year regression of nests and flight, Erwin and Ogden 1979 computed a mean error rate of just 13% for eight colonies larger than 150 nests, but for five smaller colonies (like this one) the mean error rate was 97%. For their study, the "error rate" is a measure of how well a single colony regression could be applied, for a single year and species. Erwin (1981) also showed different regression models by species and colonies within a single year. A review of the literature found no study that tested the flight-line methodology over multiple years.

Although flight-line counts can be conducted by volunteers from a distance, without disturbing the colony, these counts have neither the accuracy nor statistical power of direct counts. The increased variation, and resultant decreased power, means that the flight-line count method is less likely to detect a change in colony size if it occurs. Additional research with a variety of colony sizes and species is needed to study the relationship between size of colony and flight activity. Because this study had large between-year differences, I also suggest that future studies be conducted for multiple years.

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