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STEPHEN A. NESBITT
Florida Fish & Wildlife Conservation Commission, Wildlife Research Laboratory

PAUL S. KUBILIS
Florida Fish & Wildlife Conservation Commission, Wildlife Research Laboratory

STEPHEN T. SCHWIKERT
Florida Fish & Wildlife Conservation Commission, Wildlife Research Laboratory

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RESPONSE OF FLORIDA SANDHILL CRANES TO NEST INSPECTION

STEPHEN A. NESBITT, Florida Fish & Wildlife Conservation Commission, Wildlife Research Laboratory, 4005 South Main Street, Gainesville, FL 32601, USA
PAUL S. KUBILIS, Florida Fish & Wildlife Conservation Commission, Wildlife Research Laboratory, 4005 South Main Street, Gainesville, FL 32601, USA
STEPHEN T. SCHWIKERT, Florida Fish & Wildlife Conservation Commission, Wildlife Research Laboratory, 4005 South Main Street, Gainesville, FL 32601, USA

Abstract: We observed the response of nesting Florida sandhill cranes (Grus canadensis pratensis) to 27 instances of nest inspection. The disturbed bird flew from the area 81% and walked 19% of the time. The median distance moved was 330 meters (range 28 to 480 meters). The median length of time the nest was left unattended following inspection was 50 min (range: 10 to 166 min). The median length of time that observers stayed at the nest was 16 min (range: 5 to 48 min). Ten of the nests inspected (40%) eventually failed to produce young. Statistical analysis focused on the direction and strength of association between various predictors and 4 disturbance-related outcomes; flying vs. walking, distance moved, time-off-nest, and nest fate. A limited sample size precluded the use of more than 2 predictors simultaneously in any of the statistical models. We found that the farther into incubation the nest was (nest age) the greater the likelihood the incubating bird would fly from the nest (r²=0.28, P= 0.064). Greater time-in nest area was associated with a longer time-off-nest (r²=0.29, P= 0.008). Greater time-in area and longer time-off-nest were both univariately associated with a greater probability of nest failure (r²=0.36, P=0.018 and r²=0.40, P=0.008 respectively). Four variables (time-in-area, time-off-nest, age of nest, whether the disturbed crane or its mate returned to the nest) considered in pair wise combinations were all significantly associated with probability of nest failure (r² range: 0.46 to 0.72). Longer time-in-area and whether the disturbed bird was the returning bird had the strongest overall association with likely nest failure (r²=0.72, P=0.010). Although the nest failure rate of 44% in the experimental nests was greater than the failure rate of 26% for a concurrently collected sample of control nests, the 2 rates were not significantly different (P=0.353). Based on these results we would recommend that crane nests be inspected in 12-13 min or less. If possible, nest inspections should occur later rather than earlier in the incubation period, carried out in a manner that increases the likelihood that the disturbed bird will walk rather than fly from the nest area, and timed to increase the chance that the non-disturbed bird will be the returning bird.

Key words: disturbance, Florida, Florida sandhill cranes, Grus canadensis pratensis, nest disturbance, nesting, sandhill cranes

In the course of investigating reproductive success in Florida sandhill cranes (Grus canadensis pratensis) we inspected active nests to record clutch sizes and describe the nest sites (Wood and Nesbitt 2001, Nesbitt et al. 2001). We assumed that the disturbance associated with these nest visits carried no increased risk of nest abandonment and would not otherwise affect reproductive success. Since we were working with an individually marked population of cranes, it was possible to evaluate the effects of nest disturbance on nest outcome (i.e. hatching). Following nest inspection we monitored the return of one of the parents to resume normal incubation duties. Our objective was to evaluate the influence of several variables associated with nest inspection on nest fate (whether the eggs hatched or failed to hatch) and make recommendations that might reduce adverse effects.

STUDY AREA AND METHODS

Our study was conducted on Paynes and Kanapaha Prairies (7,300 and 650 ha, respectively) in Alachua County, north-central Florida. Both sites supported a mixed community of emergent freshwater habitat, open pastures, and natural grasslands. The dominant aquatic vegetation in the shallower areas was maidencane (Panicum hemitomon), pickerelweed (Pontederia cordata) and smartweed (Polygonum spp.). Scattered within the wetland community were clumps of woody vegetation: water willow (Decodon verticillatus), willow (Salix spp.), and buttonbush (Cephalantus occidentalis). In the deeper water areas were sedge docks (Nuphar luteum) and white water-lily (Nymphaea odorata). Bahia grass (Paspalum notatum) and carpet grass (Axonopus affinis) predominated in open pastures. A mixture of hardwoods, especially live oaks (Quercus virginiana), bordered the pastures.

We captured adult members crane pairs during the non-breeding season with the use of oral tranquilizers applied to whole corn bait (Bishop 1991). Each bird was banded and marked with a unique combination of colored plastic bands for field identification (Nesbitt et al. 1992). In addition we equipped some adults with leg band mounted radio transmitters (Melvin et al. 1983). We determined sex by observing posture and voice during unison calling (Archibald 1976). Cranes were returned to the capture area after recovering from the effects of the drug. We located nests in 3 ways: by aerial survey with fixed wing aircraft over known nesting habitat, by walking in

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on radio-instrumented birds that we suspected were incubating, or by observing the non-incubating adult on the nesting territory until a nest exchange occurred. We visited nests to record clutch size, vegetation characteristics at the nest, and surrounding habitat. Nests in this study were visited as part of other studies (Nesbitt 1988, Nesbitt and Carpenter 1993) as a result their selection was based on accessibility or priority for information on a particular nestling. This study covered a span of 10 years with small annual sample sizes, therefore year effects could not be controlled for. We recognize, that had we been designing this study to address only the question of nest disturbance we would have been more systematic in our approach.

Prior to a nest visit we would position an observer to monitor the nest without alerting the incubating bird. With the observer in position we approached the nest and flushed the incubating bird. We noted its band colors and behavior as it departed the nest. The pre-positioned observer, using a 20x - 50x spotting scope, recorded manner of departure (walked or flew) of the departing bird and how far it moved from the nest site. We also recorded date, time of day, number of nest inspectors, time we spent within 125 m of the nest area (Wood 2001), time before a bird returned to incubation, and identity of the returning bird. We defined nest age as the number of days into incubation, if known, when the inspection occurred. Each year a group of nests that were located from the air, but not visited, served as controls. We followed the fate of each inspected nest and each control nest to determine if hatching occurred, and if not, the likely cause of nest failure.

Statistical analysis focused on the direction and strength of association between various predictors and 4 disturbance-related outcomes (flying versus walking from the nest, distance moved from the nest area, time off nest, and nest fate (i.e. hatching or failure to hatch) of the nest. Due to sample size constraints, no more than 2 predictors were considered simultaneously in any statistical model. We used least-squares linear regression (Rosner, 1995) to evaluate associations between predictors and each of the numeric outcomes (distance moved and time-off-nest). Residual plots and Box-Cox analysis (Box and Cox, 1964) indicated that linear regression model fits were greatly improved when distance moved and time off nest were log-transformed prior to analysis. We used logistic regression (Agresti, 1990) to evaluate associations between predictors and each of the binary outcomes (flying or walking and nest success or failure). Residual plots and results of the Hosemer-Lemeshow goodness-of-fit test (Hosemer and Lemeshow, 1989) indicated that logistic regression model fits were greatly improved when the numeric predictors, time in area, time off nest, and distance moved were log-transformed prior to analysis. As a means of characterizing the strength of association and statistical significance of various model fits, we reported the adjusted Pearson \( r^2 \) (Rosner, 1995) and the overall model F-test P-value (Rosner, 1995) for linear regression model fits, and the maximum rescaled generalized \( r^2 \) (Nagelkerke, 1991) and the overall model score test P-value (Agresti, 1990) for logistic regression model fits. Because sample sizes varied slightly among the various models fitted to the available data (see table 1), the use of information criteria (such as the Akaike Information Criterion [Burnham and Anderson 1998]) to assess model adequacy could not be effectively applied. We used the Pearson \( \chi^2 \) test (Rosner, 1995) to compare nest failure rates between the sample of inspected (experimental) nests and the concurrent sample of undisturbed control nests.

With one exception, all nest inspections were unique with regard to the nesting pair observed. One nesting pair was observed in 2 different nesting seasons. The 2 observations for this nesting pair were assumed to be independent.

RESULTS

From May of 1990 through May of 1999 we monitored inspections of 27 nests and identified another 30 nests that served as controls. The predictors we considered are listed in Table 1. The number of inspectors that visited the nest ranged from 1 to 5. Males were incubating 17 and females 10 of the nests we inspected. We monitored the return of a crane to the nest and the resumption of incubation in 26 of the 27 inspections; in one case a crane never returned to the nest. The returning bird was not always the same one that left the nest. In one instance the sex of the returning bird could not be determined and in 10 (40%) of the remaining 25 cases the crane that returned was not the one that had been disturbed from the nest. Twenty-two of the disturbed birds flew from the nest area, the other 5 walked away from the area without flying. The estimated distance that the disturbed bird moved from the nest ranged from 28 to 480 meters; the median distance moved was 330 meters. The time spent in the nest area varied from 5 to 48 min with a median of 16 min. Time spent in the area by nest visitors was influenced by how difficult it was to access the nest.

Fifteen (56%) of the 27 inspected nests hatched, 10 (37%) were abandoned, 1 was flooded, and 1 contained infertile eggs. Seventeen (57%) of 30 control nests hatched, 7 (23%) were abandoned, 3 flooded, 1 contained infertile eggs, and 3 nest were depredated. Before analysis we adjusted the samples to account for nests that failed from natural causes, leaving us with 25 experimental nests and 26 control nests. Of the 26 control nests there were 3 nests that were depredated. There is a potential that abandonment could have preceded predation; consequently, when we conducted analysis of nest fate using the experimental and control groups, we made those comparisons with and without including the depredated control nests. When we looked at the raw data we saw that 2 of the 25 experimental observations, one with the greatest time-in-area and the other with greater time-off-nest, both had positive outcomes which are paradoxical. These 2 observations with extended times were atypical compared to the others; one was a hatching nest and at a vehicle became stuck in the area of the other, removing these 2 left us with a sample of 23 experimental nest inspections.
For this analysis sample of 23 nests the median time-off-nest following disturbance was 50 min (range: 10 to 166 min). For nests that hatched, median time-off-nest following inspection disturbance was 33.5 min (range: 10 to 85 min) and 87 min (range 22 to 147 min) for nests that were abandoned. Time-off-nest was positively correlated ($r^2=0.398$, $P=0.008$,) with nest failure (Table 2).

Median time-in-area was 16 min (range: 5-48). For nests that hatched median time-in-area was 12.5 min (range: 5 to 48 min), and 19 min (range: 13 to 32 min) for nests that failed. Time-in-area was positively correlated with nest fate ($r^2=0.356$, $P=0.008$) although the strength of association was slightly lower than was observed for time-off-nest. It seems intuitive that as time-in-area increased the time-off-nest would also increase and when they were compared time-off-nest increased as time-in-area increased and the relationship was significant ($r^2=0.291$, $P=0.008$).

The median distance cranes moved from the nest during inspection was 330 meters, 5 birds walked and 22 birds flew from the nest area. Males walked from the nest 17.6% and flew 76.5% of the time. The median estimated distance females moved for the nest was 460 meters (range: 55 to 480 meters) and the median amount of time they stayed off the nest was 52.5 min (range: 10 to 135 min). Sex of the incubating bird did not significantly influence the distance the bird moved from the nest when disturbed ($P= 0.339$) or time spent off nest ($P= 0.861$).

Two additional variables had some influence on nest outcome: the probability of nest failure decreased as age of nest increased ($r^2=0.196$, $P=0.087$), and the probability of nest failure increased ($r^2=0.168$, $P=0.112$) if the same bird that was disturbed from the nest returned rather than its undisturbed mate (Table 2).

Of the remaining variables in Table 1 there were some others that were associations with outcomes of interest. Distance moved from the nest area increased if the bird flew rather than walked from the area ($r^2=0.311$, $P=0.009$) and there was a nearly significant positive relationship ($r^2=0.28$, $P=0.064$) between increasing age of the nest and the bird flying rather than walking when disturbed from the nest.

When we looked at the influence of 2 predictors on nest fate simultaneously (Table 3) there were some notable associations. The probability of nest failure increased with increased time-in-area and increased time-off-nest ($r^2=0.538$, $P=0.016$).

### Table 1. Variables and response by nesting sandhill cranes to nest inspections in Florida: 1990 to 1999.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Range or Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of nest (days)</td>
<td>25</td>
<td>17</td>
<td>7.4</td>
<td>15</td>
<td>7 – 32</td>
</tr>
<tr>
<td>Number of inspectors</td>
<td>26</td>
<td>1.9</td>
<td>0.9</td>
<td>2</td>
<td>1-5</td>
</tr>
<tr>
<td>Time of day (hours)</td>
<td>27</td>
<td>1204</td>
<td>3.2</td>
<td>1040</td>
<td>0841-1808</td>
</tr>
<tr>
<td>Time-in-area (minutes)</td>
<td>27</td>
<td>17</td>
<td>8.9</td>
<td>16</td>
<td>5 – 48</td>
</tr>
<tr>
<td>Time-off-nest (minutes)</td>
<td>27</td>
<td>60</td>
<td>45</td>
<td>50</td>
<td>10-166</td>
</tr>
<tr>
<td>Distance moved (meters)</td>
<td>25</td>
<td>324</td>
<td>168</td>
<td>330</td>
<td>28- 480+</td>
</tr>
<tr>
<td>Inspection date</td>
<td>27</td>
<td>14 April</td>
<td>20.3</td>
<td>13 April</td>
<td>3/12 – 5/17</td>
</tr>
<tr>
<td>Departure behavior: walk / fly (%)</td>
<td>27</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>5 (19) / 22 (81)</td>
</tr>
<tr>
<td>Incubating bird: male / female (%)</td>
<td>27</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>17 (63) / 10 (37)</td>
</tr>
<tr>
<td>Returning bird: same / different (%)</td>
<td>25</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>15 (60) / 10 (40)</td>
</tr>
<tr>
<td>Fate: hatched / abandoned / other (%)</td>
<td>27</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>15 (56) / 10 (37) / 2 (7)</td>
</tr>
</tbody>
</table>
Although slight positive correlation was noted between time-in-area and time-off-nest ($r^2=0.291$, $P=0.008$) the univariate logistic regression coefficient for each of these predictors differed only slightly from the respective coefficients estimated for the 2-predictor model, suggesting that time-in-area and time-off-nest are providing independent information about nest fate in the 2-predictor model. The probability of nest failure increased with increased time-in-area or time-off-nest, if the returning bird was the one disturbed from the nest ($r^2=0.724$, $P=0.01$ and $r^2=0.580$, $P=0.012$, respectively). The lower the number of nest days and the greater the amount of time-in-area the greater the likelihood of nest failure ($r^2=0.540$, $P=0.03$). The same was true for the age of nest and time-off-nest; with decreased age and increased time-off-nest, the likelihood of failure increased ($r^2=0.459$, $P=0.03$).

The rate of nest abandonment (44%), in the experimental nests, was greater than the rate (26%) for the control nests. The rates did not differ significantly ($P=0.35$) with the 3 depredated nests excluded from the control sample; with them included the difference less significant ($P=0.73$). We assumed the rate of abandonment of the control nests (26%) was normal and we used this as an acceptable probability of abandonment (PA). Given the association between time we spent in the nest area and the time the birds spent off the nest (which was related to nest outcome) we were interested in estimating how much time could be spent in the nest area without raising the PA above an acceptable level (i.e. a level similar to the control nests). The PA, based on a logistic regression model, was 23% after 12-13 min spent in the nest area. After 25 min the PA rose to 78%. We then added the mitigating affect on PA of the other 2 variables that most influenced PA (nest age, returning bird: table 3) in a two-variable model. At 12 min, if the returning bird were the undisturbed bird, the PA was <1%; at 25 min it was 23%. After 12 min in the area, if the nest were ≥25 days of age, the PA was 3% and at 25 min it was 37%.

**DISCUSSION**

Time-in-area and time-off-nest were the variables that had the greatest univariate effect on nest fate of sandhill cranes. Though intuitively they would seem closely related the 2 variable seemed to be acting somewhat independently when accounting for nest fate. Not surprisingly, the greater the time-off-nest the more likely it was that the nest would fail. The variable that correlated most closely with time-off-nest following inspection was the amount of time spent in the nest area during nest inspection. However, the negative effect of time-off-nest was mitigated by some other factors. If the nest was late in incubation the negative effect was reduced, perhaps because later in the incubation period eggs may have an increased

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**Table 2. Probability of nest failure explained by variable in one-predictor logistic regression models for Florida sandhill crane nest inspected: 1990 to 1999.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Direction of association</th>
<th>$r^2$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-off-nest</td>
<td>↑</td>
<td>0.398</td>
<td>0.008</td>
</tr>
<tr>
<td>Time-in-area</td>
<td>↑</td>
<td>0.356</td>
<td>0.018</td>
</tr>
<tr>
<td>Age of nest</td>
<td>↓</td>
<td>0.196</td>
<td>0.087</td>
</tr>
<tr>
<td>Same bird returning</td>
<td>↑</td>
<td>0.168</td>
<td>0.112</td>
</tr>
</tbody>
</table>

**Table 3. Probability of nest failure explained by variables in two-predictor logistic regression models for Florida sandhill crane nest inspected: 1990 to 1999.**

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Direction of association</th>
<th>Variable 2</th>
<th>Direction of association</th>
<th>$r^2$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-in-area</td>
<td>↑</td>
<td>Same bird returning</td>
<td>↑</td>
<td>0.724</td>
<td>0.010</td>
</tr>
<tr>
<td>Time-off-nest</td>
<td>↑</td>
<td>Same bird returning</td>
<td>↑</td>
<td>0.580</td>
<td>0.012</td>
</tr>
<tr>
<td>Time-in-area</td>
<td>↑</td>
<td>Age of nest</td>
<td>↓</td>
<td>0.540</td>
<td>0.030</td>
</tr>
<tr>
<td>Time-in-area</td>
<td>↑</td>
<td>Time-off-nest</td>
<td>↑</td>
<td>0.538</td>
<td>0.016</td>
</tr>
<tr>
<td>Age of nest</td>
<td>↓</td>
<td>Time-off-nest</td>
<td>↑</td>
<td>0.459</td>
<td>0.031</td>
</tr>
</tbody>
</table>
viability (embryo vigor). Also we found that if the returning bird was the mate of the bird that was flushed from the nest, and this happened 40% of the time, time-off-nest was lessened as a consequence of time-in-area. One possible explanation for this was that if the inspection coincided with a normal nest exchange (nest exchange occurs several times during the day) the bird arriving at the nest to assume incubation duty could be unaffected by any disturbance associated with the inspection. If there were a minimum amount of time that a disturbed bird will wait before attempting to return to the nest following an inspection, then time-in-area would be less of a factor if the naive mate were the returning bird. Time-off-nest was also reduced if the disturbed bird walked rather than flew from the nest. A bird that walked from the nest tended to stay in the vicinity and could see us leaving the area or, simply because of proximity, they returned to the nest more quickly than a crane that flew from the nest area.

Our sample sizes were admittedly small and a larger number of observations would have lent greater confidence to some of these conclusions, nevertheless, based on these data we can make some recommendations. First when checking crane nests it is best to stay in the nest area no more that 13 min. It would be preferable, if the age of the nest were known, to conduct nest inspection later rather than earlier in the incubation period. Predicting when a nest exchange is about to occur might be difficult and would require some additional prior work; however having the undisturbed bird arriving to assume incubation reduces the negative effect of time-in-area. In addition approaching the nest slowly, allowing the incubation bird time to walk rather than fly from the nest tends to lessen the time-off-nest and reduce chance of nest failure. We believe that if these suggestions are followed the deleterious impacts of nest inspections on nest fate will be reduced.

There have been other attempts to evaluate the impacts of disturbance on nesting wildlife and produce recommendation to minimize those effects, though most dealt with response and approach distance. Evaluations of disturbances to nesting bald eagles (Haliacetus leucocephalus) have produced information on average flushing distances (Fraser et al. 1985, Grubb and King 1991). Such data have then been used to develop set-back distance for use in national and regional habitat management plans (U.S. Fish & Wildlife Service 1981). Anderson (1988) recommended that to minimize effects on nesting brown pelicans (Pelecanus occidentalis) human activity should be no closer than 600 m to a nesting colony. In a study of 15 species of colonially nesting water birds Rodgers and Smith (1995) found that walking produced a greater effect that mechanized approach. They used a formula for determining setback for each species but in general they recommended a set-back distance of 100 m for mixed species colonies of wading birds and 180 m for mixed gull and tern colonies. We did not look at distance of approach as a variable in our study. The results of such a study would be useful to have as the frequency of encroachment of development into crane nesting habitat in Florida has increased dramatically in recent years.

Our sample sizes were admittedly small and a larger number of observations would have lent greater confidence to some of these conclusions, nevertheless, based on these data we can make some recommendations. First when checking crane nests it is best to stay in the nest area no more that 13 min. It would be preferable, if the age of the nest were known, to conduct nest inspection later rather than earlier in the incubation period. Predicting when a nest exchange is about to occur might be difficult and would require some additional prior work; however having the undisturbed bird arriving to assume incubation reduces the negative effect of time-in-area. In addition approaching the nest slowly, allowing the incubation bird time to walk rather than fly from the nest tends to lessen the time-off-nest and reduce chance of nest failure. We believe that if these suggestions are followed the deleterious impacts of nest inspections on nest fate will be reduced.

ACKNOWLEDGMENTS

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LITERATURE CITED


